

December 2003

SERVO

Before R2-D2, There Was R1-D1

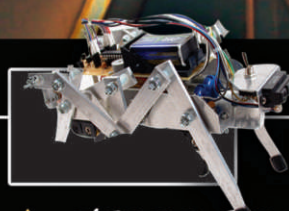
MAGAZINE

T-REX 2003 STEEL THE KING

Inside: Robots That ...



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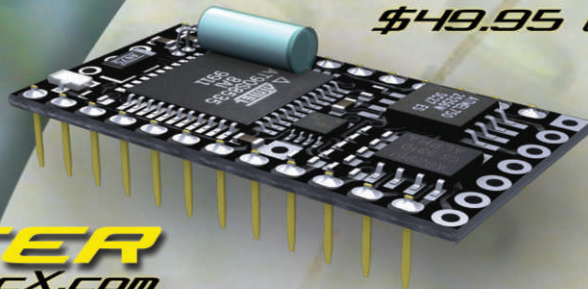


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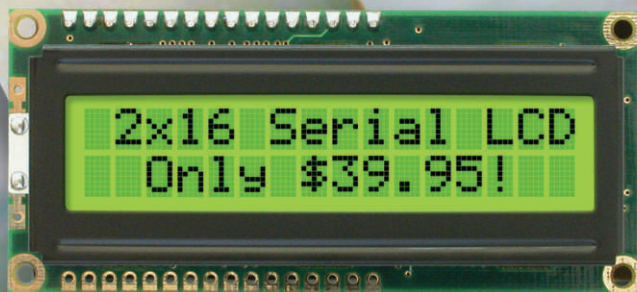
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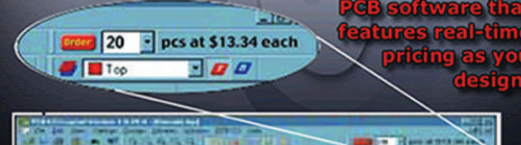
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12.2003



8 i-Cybie: Dog On Fire

20 WORKING WITH UHMW

40 NAVIGATING THE MIND FIELD

60 SUMO TRACTION IS $F=\mu N$

Cover Photo by John Graham

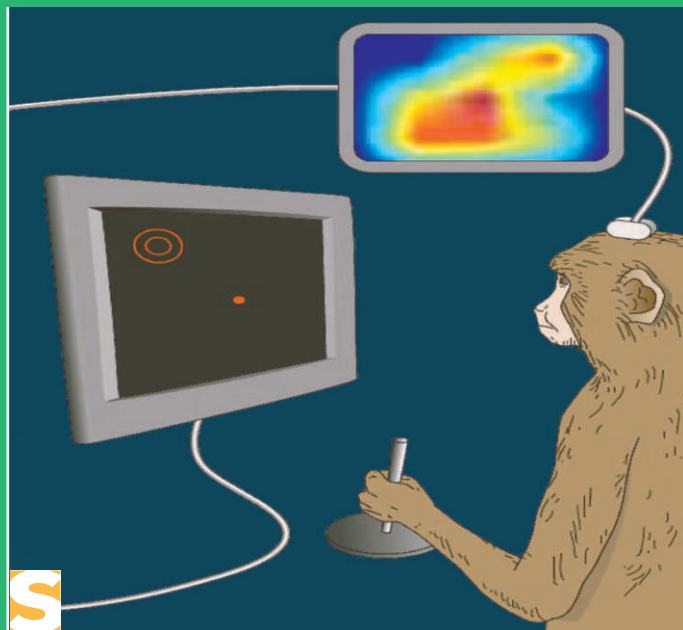
table of contents

Vol. 1 No. 2



Lucky The Dinosaur

Coming 01.2004 in **SERVO**



projects

- 14 Sonar Mapping Module
- 34 Hexatron — Part 2
- 52 Teaching Your Robot

columns

- 6 Mind/Iron
- 28 GeerHead
- 39 Menagerie
- 48 Ask Mr. Roboto
- 58 Robytes
- 68 Robotics Resources
- 73 Appetizer
- 76 Events Calendar

departments

- 6 Publisher's Info
- 7 Bio Feedback
- 24 New Products
- 47 Robot Bookstore
- 77 Robotics Showcase
- 78 Advertiser's Index

Mind / Iron



by Dan Danknick

I imagined that working on a giant, autonomous robot would be really hard. Turns out, it was worse than I could have imagined. From the first meeting in December 2002, my team considered the issues involved in solving the DARPA Grand Challenge (DGC) — that 250 mile robotic off-road race between Barstow, CA and Las Vegas, NV that is scheduled for March 13, 2004. First place earns you a cool \$1 million, second, just a dusty sensor lens.

Things were going pretty well — we had our 20 or so advanced degrees concentrated in a dozen team members, the radar ground profiles, the vehicle dynamics simulations, and of course, the six digit sponsorship deal.

Then the bomb dropped from the .mil domain. Our technical paper had been approved by DARPA but due to a sudden change in plans, only a small subset would see Race Day. Various new screenings had been imposed and now, only 20 teams would gather at that secret starting line.

I guess this really shouldn't have surprised me. Earlier, at the February 22nd competitors' conference, I engaged in some social engineering. After the public comparison of brainpan sizes was done, I was buying drinks for the DARPA representatives on the roof of the Peterson Museum and enjoying the conversation.

Guess what I learned? *One active DARPA project is to engineer moths to smell the explosives in land mines and identify their position. Makes sense. Oh, and the \$1 million prize for the DGC is just the signature authority limit — this autonomous vehicle is*



TEAM TERRAHAWK

worth much more. Interesting. And we're tired of long lead times and enormous price tags from defense contractors for machines like this. Danger, Will Robinson.

She didn't have to say it — and if she did, my mind was already reeling. The legions of Linux programmers and garage machinists were being held up in the face of nine-layer deep management structures, block long Gantt charts, and 10 digit development budgets. I just never expected DARPA to make this magnitude of a switch, this late in the game. Now we're in a pickle.

So here's my solution: Yahoo! co-founder Jerry Yang should announce the Yahoo! Grand Challenge and offer a \$2 million first prize for a similar effort. He'd have an instant pool of competitors. And, the robots could even use the "driving directions" section of his street map service, once it is augmented to work with GPS coordinates.

The PR for Yahoo! would be huge. And at least Jerry already declares himself a yahoo in his management profile.

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BIO → FEEDBACK

Dear *SERVO*:

I just received my premiere issue of *SERVO*. I'm very impressed and look forward to more. I just recently returned to electronics as a hobby and have included amateur robotics to the list. I'm currently building my first bot. It is a simple line follower built in a sandwich container, but it is a reminder of why I enjoyed electronics to begin with. I hope Santa will bring me a subscription to both *SERVO* and *Nuts & Volts* (LOL). Thanks again.

Jon Farris
Spokane, WA

Dear *SERVO*:

SERVO has a great future if the initial copy is any indication of things to come. I have read the first issue cover to cover. It is an excellent resource for a wide variety of robotics experiments. Very well done.

Jack Lawrence
La Center, WA

Dear *SERVO*:

Our first issue of *SERVO* came in the mail on Saturday and all three of us were taking turns checking it out. You did an absolutely fantastic job! The magazine is everything that anyone involved, or wanting to be involved, in robotics could ask for. From the really cool cover through all of the great articles and the exciting advertisements, you have shown that all aspects of robotics are encompassed in this outstanding publication! Thank you for all of your hard work in making *SERVO* what it is and will be for many years to come.

My wife Deb is already saying that she will let all of the kids on the team and in the club know that this is something that they need to get. She said that this will make a great gift for the upcoming holidays.

I brought it in to work today and I have already had



The Austin High School "Medical Madness" Robotics Team takes a break following the completion of the 2003 Tennessee Valley BEST Robotics competition held October 25 at the University of Alabama in Huntsville. This year's game is named "Transfusion Confusion" and was held six weeks after the Kick-off Day when the playing field and game specific rules were revealed. The team will advance to the regional competition held at Auburn University on November 15. Additional information about the competition can be found at www.tennesseevalleybest.org or www.southsbest.org

someone here say that they need to get it for their son. I will show it around, though I need to keep hold of it so I can bring it back to my kids Evan and Bryce this evening. That could prove hard to do! Very cool!!

Once again, great job! I knew that it would be excellent and it certainly is. Thanks!

Bill Woolley
Temecula, CA

Mind / Iron ...

Lather, Rinse, Repeat

I imagined that working on a monthly magazine about robotics would be really hard. Turns out, it's only *pretty* hard — the nice thing is that you don't have enough time to fall in love with the details, and develop a bias toward them. Zealous enthusiasm is reserved only for the underlying idea — the core principle.

One of the reasons I work on

SERVO is because of the potential it holds to unite diverse areas of study. Machinists get a chance to think about software algorithms and comp-sci grad students learn about aluminum alloys. Is there a negative side effect to either group? No, because the core principle is obeyed: Thinkers get a chance to think.

This issue of *SERVO* is diverse. The GeerHead column pairs a nano sumo robot with the mighty Robosaurus. Playing an octave higher is an essay on human consciousness, which I

recommend digesting for a week before digging into Dr. Comeau's discussion of intelligence, and whether it's even applicable as a machine quality. Of course, you can cleanse your palate with the playful i-Cybie and the clever creation of its Z/2 personality upgrade.

Is my goal to bake your noodle? No, but if you want to think about old things in new ways, and new things in unimagined ways, I'll make sure you get right to the core principle. Every month. **SV**

i-Nside





by Nicholas Blye

If you're reading *SERVO*, you might be lucky enough to remember the robot i-Cybie — or luckier, actually own one. If not, set *SERVO*'s WayBack machine to the February 2000 International Toy Fair ...

Looking into a street side Manhattan window rented by a Chinese toy company — Silverlit Electronics — you'd see the first version of a robot that's since developed a loyal following of amateur robotics fans, professional developers, and anyone else who thinks it's the 21st century — and everyone should have an affordable robot.

Measuring about a foot long with 16 articulated joints, Silverlit promised it would walk around, perform tricks on command, and also happen to sell for \$1,350.00 less than the nearest competitor. i-Cybie's retail was just \$150.00.

Right then, right there, a US Toy Company — Tiger Electronics — negotiated for a development and distribution license, stuck Tiger's logo on the display window, and moved several robots to their own exhibit space.

Like most prototypes, i-Cybie wasn't exactly fully functional. According to Silverlit, it could walk and per-

form tricks, but this would be after it was actually developed from a prototype into a real consumer robot. Well, real robots don't grow on trees — unless you count the ones picking oranges in Orlando.

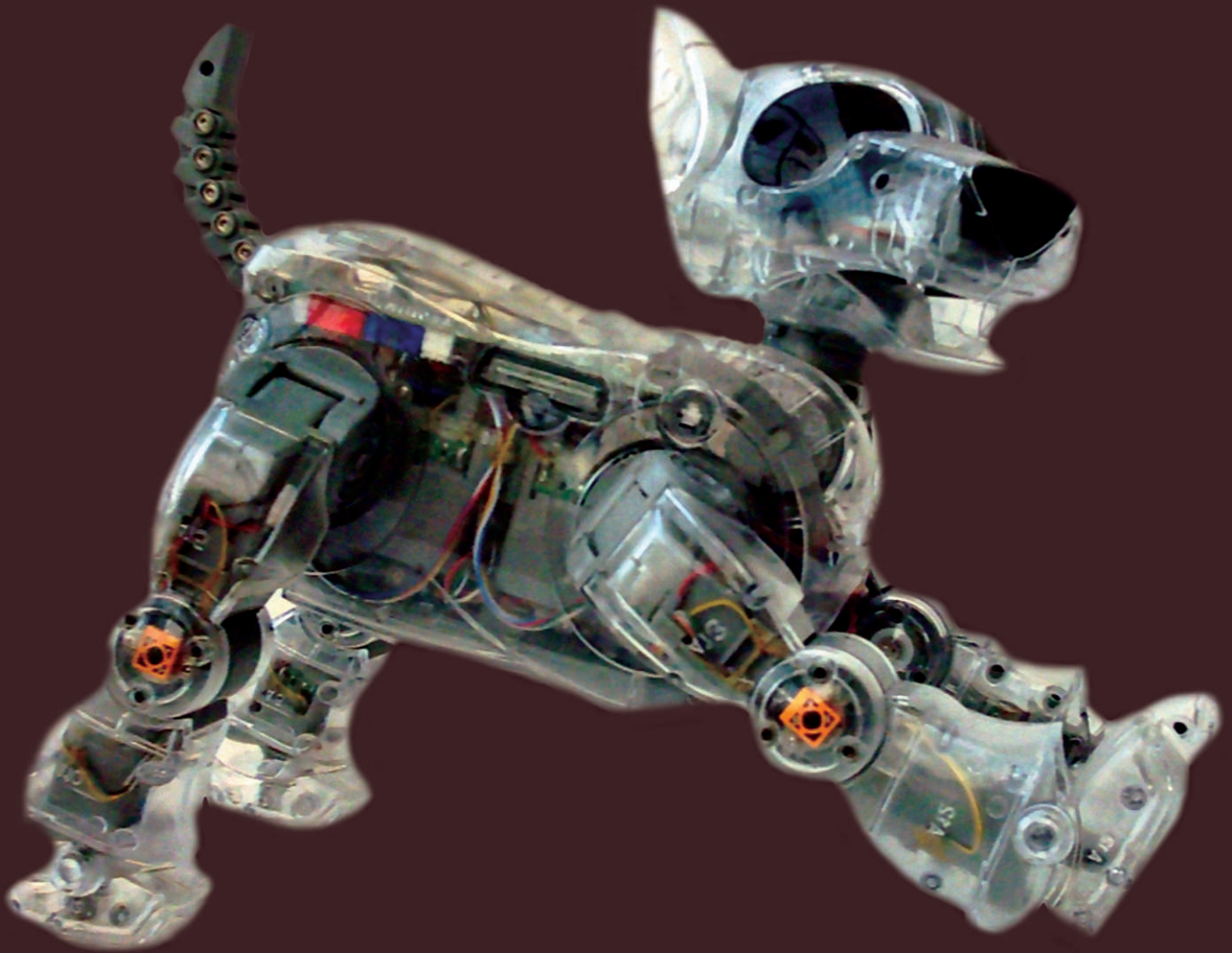
Lawyers? Smiling?

To turn i-Cybie into a real product, Tiger and Silverlit turned the robot over to Andy Filo, creator of Furby, and a few other products that sold incredibly well.

The first step taken was to replace the head — not because it didn't work, but because of the "please don't sue me Sony, we didn't mean it ... really" design. The new design looked more like a distinctive robot and not like a knockoff. The next step was making the robot actually walk, and adding a wide array of movements. These were not programmed by computers, but by human puppeteers that meticulously created lifelike motions and reactions.

The short version of the saga is after production and design glitches causing one missed deadline after another, i-Cybie was finally released on July 31, 2001 at FAO/Schwarz in the New York area ... over a year late.

Robots like i-Cybie are an
important development in
affordable, personal robots.



Robots on a Budget

i-Cybie was introduced with few ads, in places you simply didn't expect to find a real robot, like K-mart and Aldi's grocery stores. The release also competed against a holiday season with the X-Box and PS2, and that's right where all the robotics money from the holiday budget went. i-Cybie's late introduction as an unknown product against two major game systems meant it simply failed to sell.

Once marked down after the holidays to \$50.00 or less, i-Cybie sold very well! The troubles didn't end there though, due to a typographic error in the manual telling owners to charge the battery for 10 hours. The maximum charge time is only 3-4 hours. A 10-hour charge resulted in a 15-minute run-time, and burned out the 12 volt NiCad battery. (Can you imagine waiting for your new robot's battery to charge for 10 hours, only to find it ran for exactly 15 minutes and you ruined the battery?) Because of this misprint, many robots

ended up on return shelves everywhere they were sold.

i-Cybie's the only robot I know that must be in a Betty Crocker recipe somewhere with ".... and bake at 350° for 10 hours before returning for a refund" printed next to its picture.

Shortly after the season ended, Tiger Electronics was closed by Hasbro and turned into an in-house brand name.

Fade Out: Act Two

Usually a product with these challenges would fade away into the "I remember the Petster Deluxe" realm of obscurity, except for one thing: Silverlit Electronics.

Everyone forgot about the actual designer and manufacturer of i-Cybie, and they had their own plans. i-Cybie was saved by a built-in cartridge port, the support of dedicated fans, and the manufacturer, who included all the features of one very flexible robot.

Silverlit started Act Two by selling accessories from the www.i-cybie.com website, and now directly from the US at www.buy-cybie.com. The first product — a NiMH battery — has a 2.5 hour run time and no NiCad recharging effects. This sold very well to the enthusiastic fans who made it past the shaky start and, of course, needed new batteries.

After a few months, Silverlit surprised even the most loyal fan by releasing every accessory promised by Tiger, and more. Among the items released was the single thing that made i-Cybie into a robot for mad scientists: a program downloader for i-Cybie cartridges. Silverlit even answered the requests for different colors by offering replacement body panels in everything from the deepest matte black to completely clear.

If you've ever wanted to see how something works, the clear shell is a luxury accessory made for you, letting you see all of the 1,400 parts in action, including everything from the eye LEDs to the tiny RS-232 pads.

The Coolest Thing

The most impressive accessory to date is one that has to be seen to be believed: a "Walk-Up Charger" that for \$50.00 lets your i-Cybie start looking around for power when its batteries are low. It then locates, navigates toward, and plugs itself in, aligning two tiny contacts with power terminals automatically, without human intervention. (When it's fully recharged, i-Cybie politely burps, disconnects itself, and walks away.)

Starting in the design stage, Silverlit, Andy Filo's team, and Tiger added these features for future expandability, and it's made i-Cybie into a unique and inexpensive robotic development platform.

How Much is that Robot in the Window?

At current market prices, for about \$100.00 you get a 16 axis programmable walking robot with autonomous charging ability. For another \$100.00, you get the ability to develop and burn your own personalities and programs directly to cartridges.

For debugging, you should also solder an RS-232 port to the motherboard (just \$10.00 in parts) — giving you a great programming platform.

If you're just looking for a fairly autonomous robot, order the Walk-Up Charger from www.buy-cybie.com. This site includes a free upgrade chip with an advanced Z/2 personal-

ity that runs instead of the factory firmware. This permanently eliminates the number one i-Cybie complaint: its factory default disposition; the same upgrade also dramatically improves the robot's interactive response.

As of this writing, new i-Cybie's are being sold at **Target.com**, on eBay, and through **buy-cybie.com** for the US and European markets. It's also available in Australia, and throughout Asia.

Silverlit has stated plans to re-release i-Cybie in various commercial markets, without the marketing failures of 2001 so the manual won't include a recipe on how to perfectly cook a NiCad battery in the comfort of your own home.

Technically ...

Out of the 1,400 parts that make i-Cybie work, here are some detailed specifications of the main components:

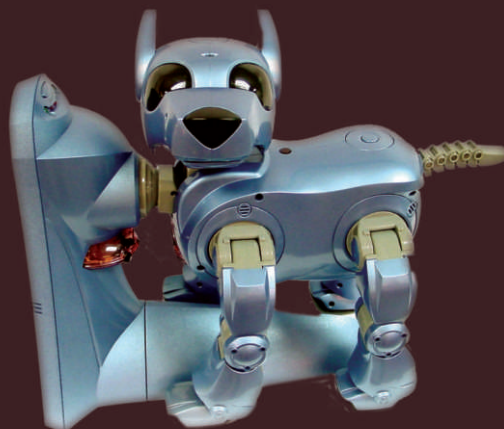
Motion Hardware

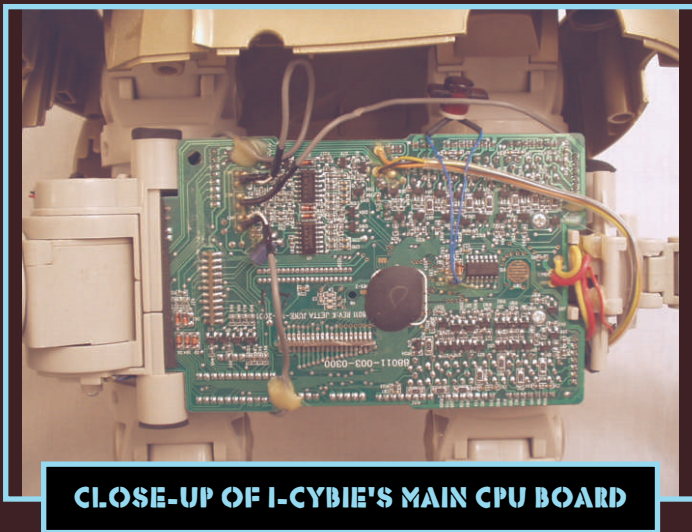
Base hardware is built on an internal skeleton, which can be seen at the joints. The outer body shell fastens to the inner skeleton and can be removed and customized in a variety of ways, including changing it completely.

The joints include 16 motors with the 12 self-calibrating leg joints wired through 1/2 H-bridge connectors. Calibrated potentiometer feedback on these joints provides positional accuracy to less than 0.5 degrees of motion.



I-CYBIE AT THE WALK UP CHARGER





CLOSE-UP OF I-CYBIE'S MAIN CPU BOARD

Built-in calibration routines operate automatically, or you can calibrate manually, if needed.

The remaining four joints — neck, head, shoulders, and tail — use small limit switches to detect the extent of motion. For instance, the neck has sensors to the extreme left, extreme right, and middle of the range of travel.

The range of motion and built-in fluid actions give the robot a wide range of flexibility, thus giving you a wide range of development opportunity.

Processor Overview

The system internals include a main CPU and two dedicated CPUs:

PRIMARY PROCESSOR: a Toshiba TLCS-900/L series. This is a 16-bit processor that handles all the hardware control functions. The processor produces about two million instructions per second. The TLCS-900 series is designed to handle multiple inputs at once, controlling several motors, registering feedback, and managing dataflow through the processor efficiently. The processor firmware is programmed in a combination of assembly and C, requiring little active RAM, with the majority of storage dedicated to sound.

VOICE RECOGNITION: A Sensory RSC-364 records voice command samples and recognizes those commands. This powerful processor isn't used at anywhere near capacity, just recognizing eight commands. The RSC-300 series is also capable of continuous recognition. But here, it is only used when voice mode is turned on by the owner or the robot is set to stop and listen for commands occasionally. The Sensory chip is a last minute addition, replacing Tigers own incomplete voice chip.

AUDIO PLAYBACK: Sound data from the internal or cartridge ROM is sent to a SunPlus sound chip in 4 bit, 8 KHz ADPCM format. The sound chip is located in the head along

with the voice recognition chip. The audio is generated through a speaker in the mouth whether opened or closed. The SunPlus chip also manages some of the sensor input, using 10 bits of data sent to the main processor.

Memory

The internal 256K is provided by a pair of SST 39VF010 flash ROM chips, with system memory expanded by matching chips in the cartridge.

Sensors

The IR Spatial array is the most visible sensor and is, in fact, used for vision. Located on the chest, this array consists of five IR emitters, sending sequential pulses of \$81, \$85, \$87, and \$89, with a single detector in the center to respond to reflected IR signals. The signals are modulated on a 37.5 kHz carrier. By detecting an IR pulse, i-Cybie can determine where obstacles are located and avoid them.

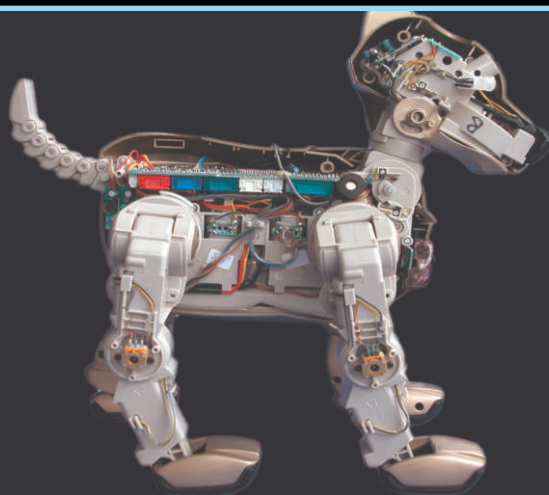
Another sensor you may notice is the back mounted light sensor reporting a byte range from 0 to 255. It's used to detect petting when your hand passes over it. This sensor also monitors the light level of the room to decide when to go to sleep. (And yes, i-Cybie snores).

Three microphones are in the body, allowing the robot to turn toward triangulated sound and recognize claps.

Internally, i-Cybie detects the voltage level of the battery, has a small reset button on the rear, battery door sensor and also a tilt sensor to detect a fall and get back up. It also knows when it's flipped over or standing on its head.

The head houses both the sound and voice chips with input from a fourth microphone used for voice recognition, tri-color LEDs for the eyes, and a contact sensor on the top of the head. The nose also contains a contact sensor and has a built-in single bit photo detector, used to detect motion during "guard duty."

I-CYBIE'S INTERNAL STRUCTURE



If you're with me so far, you recognize decent sensors, extremely flexible movement, and the fact it's designed to be reprogrammed and inexpensive. So what's i-Cybie missing?

If I Only Had a Brain ...

A stock i-Cybie is like the Scarecrow — missing a brain. It's there; it's just not used by the default firmware.

The built-in actions are very fluid. The robot is very flexible and most hardware features work as expected. But the mood-logic seems to have a permanent case of Robotic Depression Disorder (RDD).

The standard personality has four moods: happy, hyper, sad, and sleepy, but it always seems to have these four moods: sad, Sad, SAd, and you guessed it, SAD. Put simply, an i-Cybie from the factory needs Robotic Prozac.

The stock firmware also performs the same repetitive actions over and over without selective responses, variety, or intelligent mood shifts.

Keeping your robot safe from the continuous threat of impending depression requires your constant interaction and attention. While that may be great for a Poo-Chi or Tekno, this is a real robot made for bipeds ages 14 and up. I don't know of anyone 14 and up who wants a very needy robot on their hands.

This is where Silverlit and the many fans supporting this robot have stepped in. New personalities that you can download and install have been created with some user-created tools.

The available tools range from an easy to use tool anyone can use to create custom personalities, to intermediate language interpreters like BASIC, and finally, full C code or even assembly if you're really feeling brave. These are all programs written by dedicated fans, and so may challenge you to add the features you want or work within the framework of each programming language's stage of development.

The easiest modification tool — "YICT" — is one I recommend to anyone examining the development of an interactive personality. By adding or changing the responses with this tool, you can customize overall or specific behavior, or completely alter the mood logic itself to eliminate an unfortunate case of robotic depression.

YICT's behavior modification is like an implantable pump of digital antidepressants, making i-Cybie one happy robot.

The great thing about these features is, for less than many basic assemble-it-yourself robot kits, you get a complete development suite:

Fully assembled and operational 16 axis robot with effective sensors

Automatic charging device for increased autonomy

Downloader to create your own cartridges

Serial port can be wired in for more advanced C programming

May I Have a Source Code with that?

The development tools were created without the release or review of the robot's source code.

This is one area where Silverlit could take a lesson from the LEGO MindStorm series, and how the release of source code to hobbyists and fans results in increased sales, new development, and a stronger foundation of supporters.

Even without the code, development with the SDK v2.0 using C works well as an effective programming tool. BASIC is an easier to use language that interprets the code and then compiles it using the SDK.

As an introduction to robotics programming, the personality editor YICT is very easy to use and the most complete tool available.

As a fully programmable robotic platform, it's hard to overlook the low entry costs and extensive features.

If ... Then ... Next ...

For the experimenter or developer, there is a range of programming options suited to any level of experience.

Start with easy to use tools, and then try more complex code in BASIC, C, or something advanced like assembly code.

Offering even a beginner the tools and hardware needed to affordably explore a full range of robotics, it's a compelling combination.

Robots like i-Cybie are an important development in affordable, personal robots.

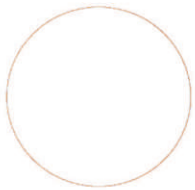
Having survived just about everything that could go wrong to a product, this is one robot that's programmed to be tougher than the sum of its 1,400 parts.

Just don't forget the Prozac ... **SV**

Sonar Mapping

by Guy Marsden

Depth Perception For a Digital Mind





There are many ways for a robot to interact with its surroundings, ranging from simple bumper switches to vision systems. Most of these systems have limitations in their field of view and/or they have cumbersome interfaces that use up valuable processor time. Sometimes, the information of an impending collision arrives too late or not at all. What is needed is a cheap and simple way to map the surroundings. And that is the subject of this article.

A Simple Design

The design that I came up with uses very few components and a one-wire interface to reduce I/O overhead on the robot's main processor. The rotating head scans continuously back and forth, using a physical limit as a reference for position.

The limit is simply a bolt sticking out of the motor flange that the rotating head drives up against to locate "home." This is simpler and cheaper than sensing home with a switch or optical sensor (though I did leave an input available for a future home sensor, if needed). An array of distance readings, representing one full rotation, is updated with every sonar reading so that the robot can poll the sensor head at will and get the most recent data. Data is transmitted serially.

Sensor Motion

Ultrasonic sonar transducers have a perfect range for this application — from about six inches to 30 feet. If the sensor can be mounted to the top of the robot on a rotational head, it will have an unobstructed field of view of its surroundings. Stepper motors are commonly available in a 1.8 degree/step type that allows 200 steps/revolution.

The use of "half stepping" achieves 400 steps/revolution, which is enough resolution to distinguish relatively small objects at a considerable distance.

Mounting

I mounted the sensor in a blue plastic sensor enclosure from SensComp (see

the table of sources for more information.) It has snaps molded in that capture the sensor very nicely and reduce the need for a lot of filing and final fitting. For tall robots, the sensor may need to be tilted down a bit. Four wires to the sensor carry power and two signals. This wire is dragged back and forth with each rotation, so it should be as flexible as possible. I used a cable from an old mouse. More adventurous folks may want to design a commutator system for transferring signals to the head, but that's mechanically tricky and fraught with problems.

The Stepper Motor

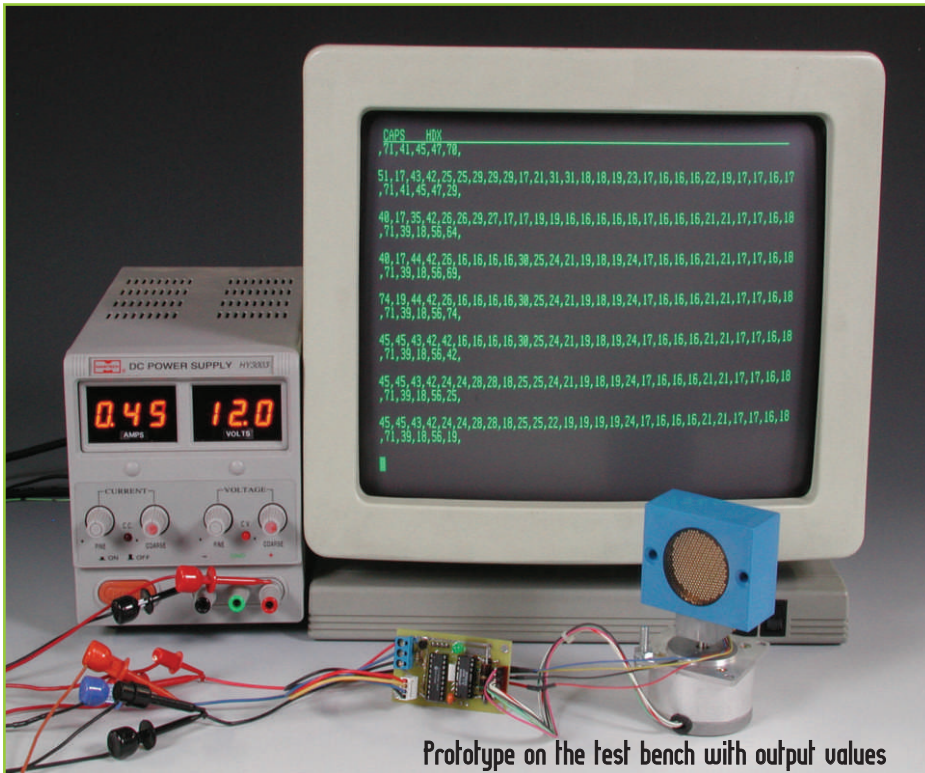
There are many types of stepper motors with a variety of coil and wiring configurations. The one I used is a six lead bipolar type, that has four coils arranged as two center tapped coils. Eight wire motors have separate wires per coil, and can be used in this application by tying the two pairs of coils together in series — but it's tricky to determine the correct phasing.

Steppers have many ways of identifying the coils with wire colors. Use an Ohmmeter to figure out which coils are connected to each other and which wires are common to each pair of phases. If you hook up one coil in reverse, the motor will just chatter and not rotate. It's a simple matter to transpose two wires and discover the correct phasing — no harm will be done to the driver chip.

Switching these coils in various sequences causes the motor to increment by steps. (See surplus sources for a list of suppliers.) Step motors with larger step angles could be used, but at the cost of decreased angular resolution.

The most common surplus stepper motors are printer pull-outs that have a 15 degree step angle — or a 7.5 degree half step yielding 48 steps — which may seem to be sufficient. These would be tempting to use at the cost of some resolution. However, most of these motors may lack the power to move the relatively large inertial mass of the head.

My design requires a motor that is a 1.8 degree per step type that can run on



Prototype on the test bench with output values

the robot's main batteries (usually 12 volts) and has reasonable power consumption.

The motor I used is rated at 20 ounce-inches at its rated 10 volts and 0.5 amp per phase (coil). This is a standard size that measures 2.25-inches in diameter by 1.625-inches deep, and usually comes with a 1/4-inch shaft. Steppers are designed with many different coil resistances to optimize them for various voltages.

Driver IC U1 is capable of driving 1.5 amp loads at up to 35 volts. However it is wise to limit the current to less than 0.5 amp, both to save battery power and to eliminate the need for a heatsink on the chip.

Since the driven load is almost entirely inertial, the power requirement is quite low. Power is controlled by a limiting resistor (R5) that can be tweaked for the desired power/performance trade-off. Calculate the value of R5 using Ohm's Law to find a combined series resistance of the motor coil and R5 that limits the total current to the desired amount.

You may find as I did that a sub-

stantially lower current than the motor's specification will still allow the motor to operate with sufficient power while conserving energy.

With R5 at 82 ohms, and a coil resistance of 20 ohms, my coil current was 125 mA — or about half the current specified for the motor. Stepper motors have more power at slower speeds and very high holding torque. Experimenting with the stepping speed and limiting resistance will yield an optimal overall performance for any given motor application. Be sure to use a resistor with more than sufficient wattage to handle the power

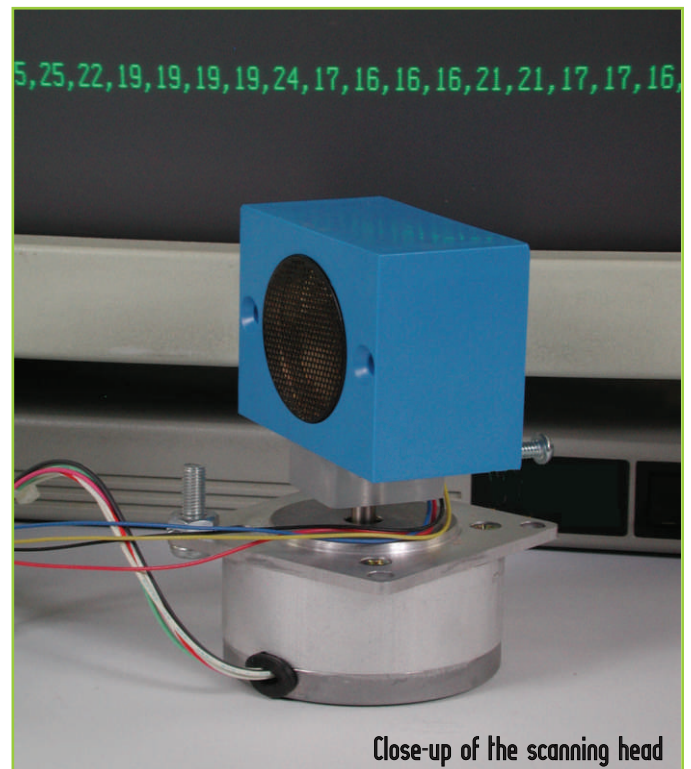
— Ohm's Law states that watts = volts squared, divided by resistance.

Motor Control

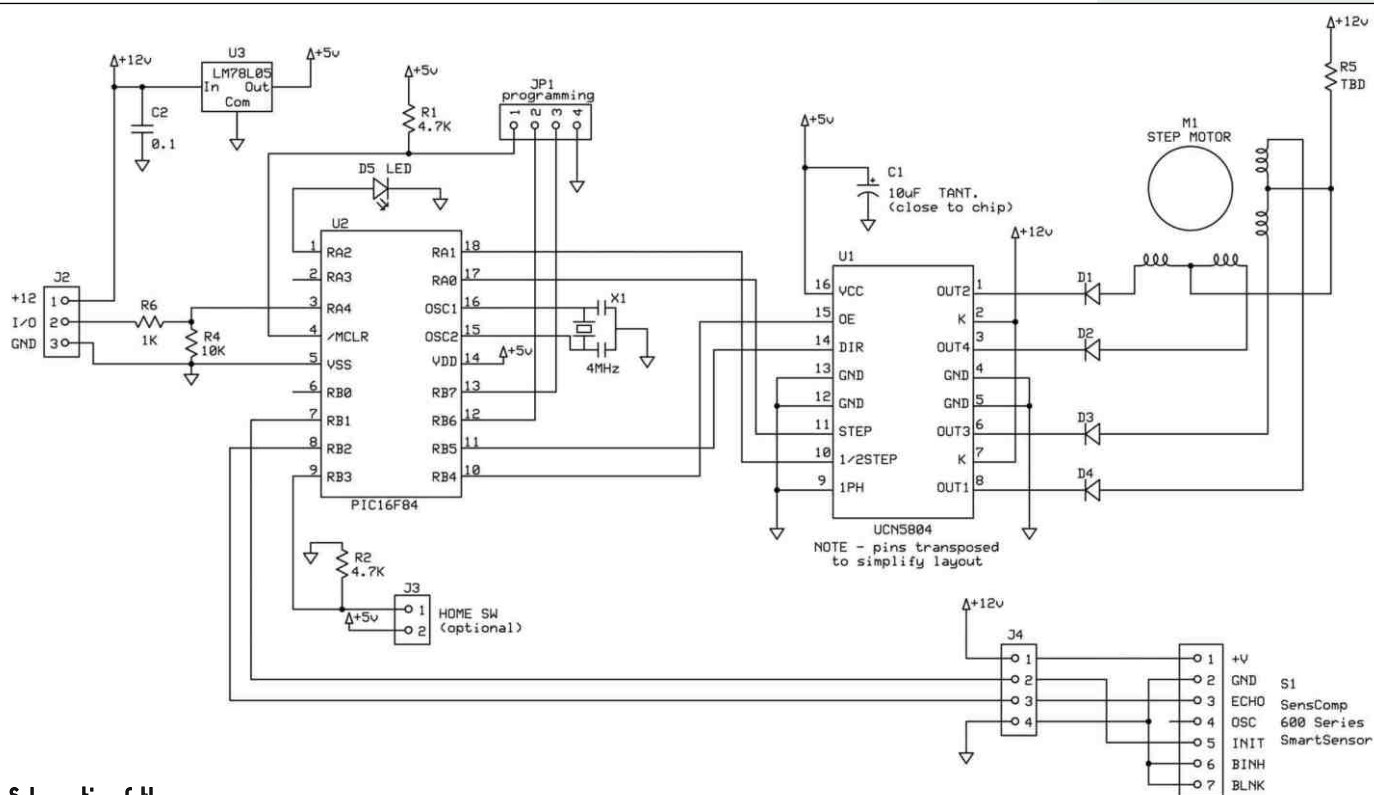
My favorite stepper motor control chip is the UCN5804 (U1) because it's cheap and simple. This part only requires four blocking diodes to limit the back EMF from the coils, and a current limiting resistor.

A tantalum filter capacitor across the logic power protects the chip from power spikes. Controls for this chip include OE (Output Enable), which is active low. I left this line LOW in my code to keep the motor active, so it won't lose position. It could be used to enable a power-saving scheme, if needed. However, the motor would need to be homed after each power down. The DIR input changes rotation direction based on level. The STEP input requires a short pulse to increment the motor one step. The 1/2STEP input, in combination with the PH input, can set up a variety of driving schemes.

By grounding PH and keeping 1/2STEP high, the motor is driven in half step mode (400 steps/rev). Setting



Close-up of the scanning head



Schematic of the sonar mapper

1/2STEP low will allow full stepping for faster movement of the motor for homing.

Sonar Signals

I used a SensComp 600 series Smart Sensor that is a re-packaged version of the "classic" Polaroid OEM kit sensor (see Resources). The two control lines are INIT and ECHO. The other inputs BINH and BLNK can be left open or grounded on the "classic" sensor. To take a reading, INIT is taken high which triggers the sensor to "ping" sixteen pulses at 49.4 kHz. The software routine then waits for the return ECHO to go high while looping to time how long it takes to arrive. Sound travels at about 0.9 mS/foot. By allowing for the return trip that is about 2 mS per foot at average temperature and humidity, distance can be calculated as a function of the echo delay time. The sensor "ping" sound is heard to the human ear as a click. The clicks are quite closely spaced as a full turn of the sensor takes around four seconds, so the perceived

sound is a buzzing at about 50 Hz.

Sonar Sampling

While this design can take nearly 400 readings per turn (minus the size of the home stop), that much data is more than is necessary for basic mapping and collision avoidance. A data array of that size would also be beyond the capabilities of most small microcontrollers. My trick is to use only 372 of the 400 steps to take 12 readings in 31 vectors that are saved in a 31 byte array. Only the closest reading is stored in the array variable for that vector as each reading is taken.

Over Sampling Theory

The reason for all this "over sampling" is to ensure that small distant objects can be seen. The Polaroid type ultrasonic sensors claim to have a viewing cone of approximately 15 degrees, and can sense a flat one foot square object at their maximum range of 30 feet — smaller objects are less easy to

resolve. Small round objects like broom handles placed at five or more feet present a poor reflector and may not be readily seen with every reading.

Additionally, the resolution of any given scan will be compromised by the turning motion of the robot, so it is best to over sample than under!

If vector #1 starts at the home sensor (which I placed at the rear of the robot) then the first value in the array represents a wedge of space of approximately 11 degrees facing the left rear. Subsequent array variables increment around the robot such that vector #15 should be almost dead ahead. The host controller can extrapolate a map from this data, or simply use it to avoid the closest object detected.

Graphic Diagram

I converted each reading to approximate inches to keep the value within a byte. Any arbitrary conversion can be used as long as you can figure out how to interpret it! I used two separate loops, one to sweep forward, and

the other to reverse, with a few extra motor steps added after the return sweep to ensure that the sensor head slams firmly against the home stop.

Code Details

I used a PIC16F84 (U2) and programmed it in PBasic, from microEngineering Labs. In circuit programming made the development much simpler, and I have made a four pin adapter to my programmer that allows me to use a four pin header to connect the programmer in circuit. Both PBasic source and the HEX image are available for download from the *SERVO Magazine* website, www.servomagazine.com

Accessing the Data

During the scan, the code checks the data line to the host processor for a high signal. Once that signal is seen, the code waits for it to return low then switches to output mode after a brief pause and sends the 31 byte array in serial format. This I/O pin of the PIC is protected with a 1K current limiter, and a 10K pulls down at the chip. The data line reverts to an input after transmitting the data. Since the PIC is fully occupied while sending the data, it stops operating the scanner motor. This brief pause in rotation gives a clear indication of when data is being accessed by the host controller. I also added an LED (D5) that lights during the data dump for a secondary visual indicator.

This is a very simple design that can give robots a detailed map of their environment for very low cost — the rest of the job is making good use of the data provided by the sensor. **SV**

PARTS LIST

U1	UCN5804
U2	PIC16F84
U3	78L05
R1-R3	4.7K Ω
R4	10K Ω
R5	See text
R6	1K Ω
C1	10 μ F tantalum
C2	0.1 μ F filter
D1-4D	1N4002
D5	Red LED
M1	12 V stepper motor, best under 1/2 amp, 1.8 degrees/step, 20+ oz-in of torque
S1	SensComp 600 series sensor, or Polaroid Ultrasonic OEM kit (includes two complete sensors) www.polaroid-oem.com

A kit of parts is available from the author, and includes the stepper motor and programmed PIC chip:
www.arttec.net/Bot/Sonar.html

SOURCES



Stepper Motor:

Part #SSM8951 is what I used, and similar ones can be found on their site.

C&H Surplus

2176 E. Colorado Blvd., Pasadena, CA 91107
800-325-9465 — www.aaaim.com/CandH/

Also investigate the surplus offerings at
Herbach & Rademan — www.herbach.com

Sonar Rangefinder:

SensComp 600 series smart sensor and
mounting box (part number 619395.)

SensComp

36704 Commerce Rd., Livonia, MI 48150
734-953-4783 — www.senscomp.com

OEM Ultrasonic Kit:

Polaroid Corp.

www.polaroid-oem.com/ultrason.htm

Also, the Ultrasonic Owl Scanner — Sonar Sensor Kit has a 180 degree field of view using a hobby servo:

Ultrasonic Owl Scanner Kit, part #3-705 for \$129.00

Sonar Explorer Kit, part #3-740 for \$74.95

Robot Store / Mondo-tronics, Inc.

124 Paul Dr., Suite 12

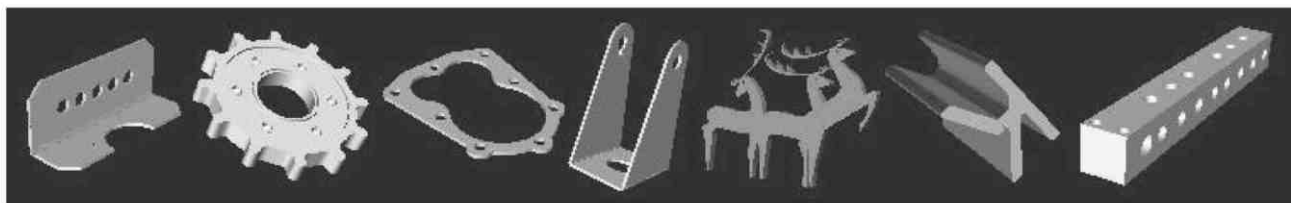
San Rafael, CA 9490

415-491-4600 — www.robotstore.com

ABOUT THE AUTHOR

Guy Marsden is a Renaissance Man who designs and makes wood furniture and artwork, electronic art, and custom electronic prototypes. See his extensive website at www.arttec.net or Email him directly at guy@arttec.net

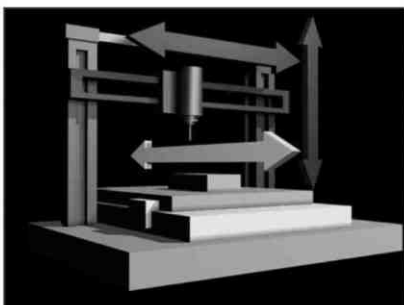
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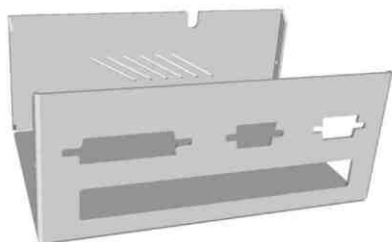


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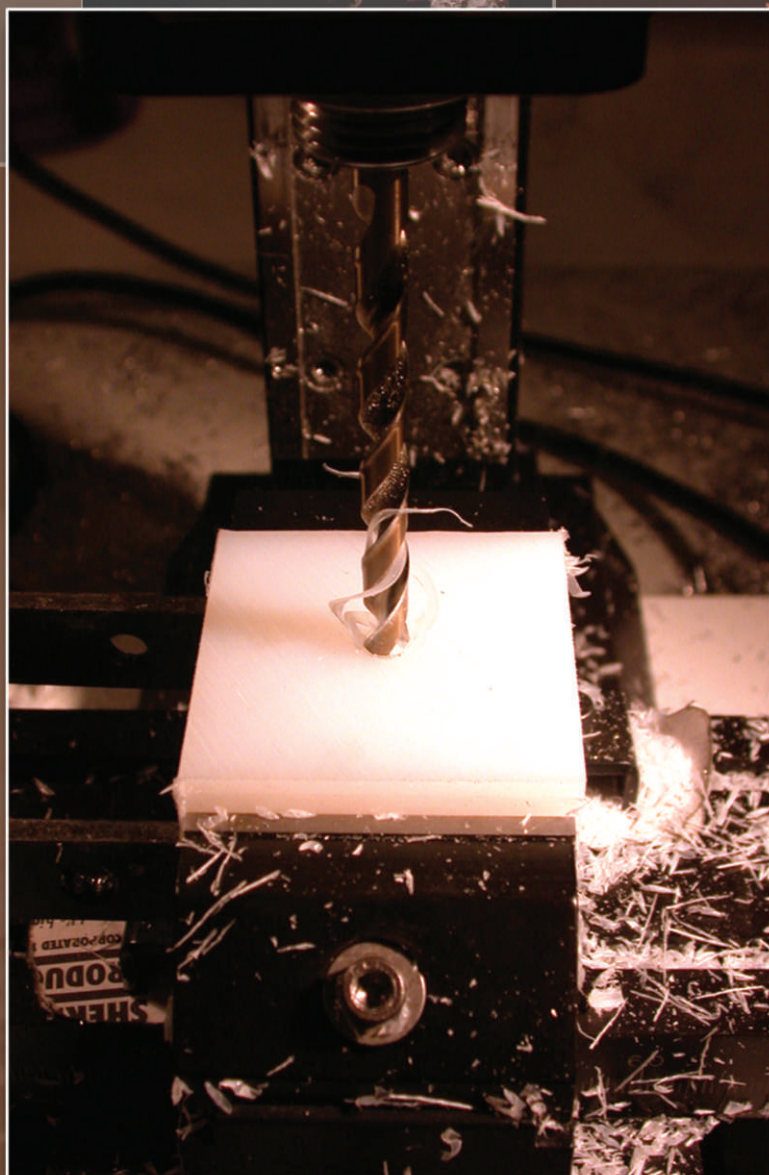
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Beta release



Working With Ultra High Molecular Weight Plastic

by Eric Scott

UHMW -

Unique material for robot building

As a builder of combat robots, I am constantly on the look-out for "the ideal material." This wonderful, mysterious product is super light, cheap and very strong, but without being overly brittle. Sadly, we are lucky to find materials that have one of these properties, let alone encompass all of them. In the search for this material, home robot builders often overlook one of the best sources of such materials — plastics. This article will focus on one such plastic: Ultra High Molecular Weight polyethylene, or UHMW for short.

UHMW has many properties of interest to the robot builder: good impact strength, a low coefficient of friction, and a high resistance to shattering. It is also fairly inexpensive, especially when compared to other commonly used plastics in the combat robot world. It can be used for many purposes in a robot.

In industry, it's most often used for chain guides, wear strips, bin and chute liners, food containers and even some power transmission components such as sprockets and bearings. In robots it finds additional use as bearing blocks, skid plates and battery spacers (Figure 1), and sometimes even as

armor or frame materials.

The key to using UHMW well in a robot is to understand its properties and to design around them. It's a fairly soft plastic, and would much rather bend than break. As such, it presents somewhat of a challenge to work with and to machine.

Of particular consideration is joining it to other parts of a robot or, for that matter, to other pieces of itself. Correct design for these joints can either make or break them — literally! In metal frame design, it is typical to remove shear loads from the bolts. While this is also good for UHMW joints, the soft plastic easily gives up its hold on screw threads.

At the very least I recommend that you do not thread UHMW. Either join it to something else entirely, or use corner blocks. A piece of square aluminum bar makes an excellent corner block when drilled and tapped at right angles (Figure 2). Use large headed screws such as button or flat heads, to help spread the load and prevent tear-through. Also be sure to use coarse thread pitches — 1/4-20 is much better than 1/4-28, for example.

To further mechanically strengthen the joint you can

Figure 1. UHMW as battery spacers.



Figure 2. Joining UHMW with Al blocks.

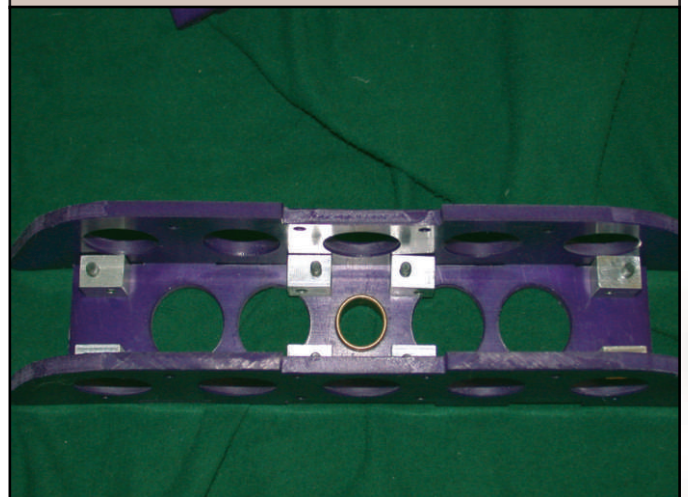




Figure 3. Increase box strength both through aluminum corner blocks and finger joints.



Figure 4. Bake up some UHMW to experiment with different colors.

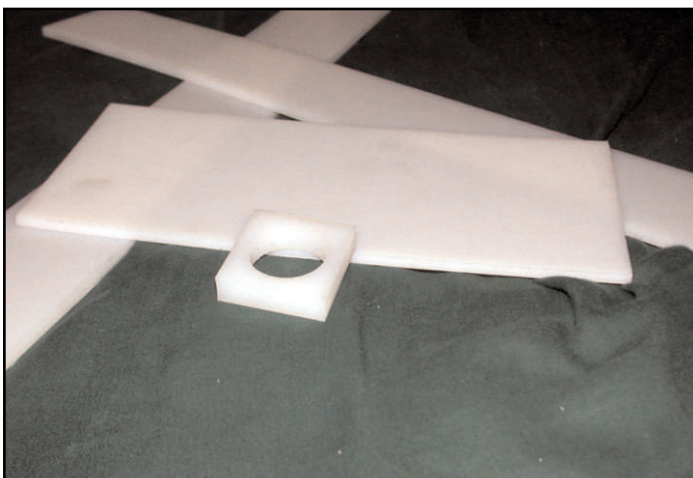


Figure 5. Raw white UHMW.

design it so that it is partially self-supporting, even without the addition of fasteners. The box or "finger" joint found commonly in woodworking is a good choice for this style of joint. Four pieces of sheet stock can be made into a hollow square beam in this fashion, using both corner blocks and finger jointing, for a very strong structure that can still absorb impacts well. The weapon assembly in my 12 pound robot is designed exactly this manner using both aluminum corner blocks and the self-supporting joint design (Figure 3).

As if having to properly design joints wasn't enough, the low coefficient of friction and high flexibility make UHMW somewhat difficult to machine. As with any shop activity please wear your safety glasses. It's easy to say "It's just plastic" but even plastic can embed itself in your eyeball at several tens of miles per hour, resulting in messy trips to the ER, and painful removal if not worse damage.

Cutting is generally the easiest of all operations. Band saws, scroll saws, and most hand saws will work as will the table saw (watch for kickback!) Use a blade with a medium to coarse tooth — finer teeth tend to slip and not bite as well. As with all UHMW operations, try and make sure your cutting edge is sharp. Be prepared for lots of little bits of floss on the cut edges. A sharp X-acto blade or a deburring tool with a bit of pressure will quickly remove this.

Drilling is where things begin to get tricky. Sharp bits are essential, as is a rigid set-up. Be sure the part is correctly restrained. I highly recommend you use a drill press here, and clamp the work securely to the table. If you are drilling many large holes in a part, do not rely on a vise to hold it still. Instead, use hold down clamps, or drill a couple of smaller bolt holes to fasten the piece down to a sacrificial block that you can then hold in the vise, or clamp to the table. This is because a piece of UHMW can flex in the vise, catch the bit, and get flung out. This generally ruins the piece and possibly your day as well!

Speaking of large holes, there are several tricks that can be used here. For moderately large sized holes (greater than 1/4-inch but less than say 3/4-inch) it is best to "sneak up" to the finished diameter by using a series of progressively larger bits. Step drills such as the ever-popular "Uni-Bit," make this easy so long as the step length is greater than the thickness of your part.

Forstner bits work well for large holes too, but beware of the spade bit. These seem like a good idea — cheap, easily available — but will almost certainly tear out, and ruin your part. Of course if you have a set of large twist drills, they will work — just be sure to progressively step up your sizes.

Milling UHMW is fairly easy. As with drilling make sure you have a rigid set-up where the work piece is firmly secured to the table or clamped in the vise. Again, as

SOURCES FOR UHMW

.....

McMaster-Carr

(732) 329-3200

P.O. Box 440

New Brunswick, NJ 08903-0440

www.mcmaster.com

.....

MSC Industrial Supply

1-800-753-7970

75 Maxess Road

Melville, NY 11747-3151

www.mscdirect.com

.....

Kenward Plastics

1-800-689-3812

1489 Atomic Rd.

N. Augusta, SC 29841

www.kenwardplastics.com

with drilling, take the time to think about where you will be removing material. Make sure that you aren't pocketing large areas that are held in the vise, as the remaining material may not be strong enough to resist flexing and could just pop out. Avoid thin, unsupported sections. If you need to cut a large area away, be sure to support the remaining thin area as it will tend to flex out of the way, to avoid being cut.

A nice sharp two-flute end mill makes quick work of UHMW. You can take fairly aggressive cuts, as long as your setup will hold it. If you are concerned about finish, try and leave about 0.010" for your final pass. You want enough material left so the tool will get a decent "bite," rather than slipping across the surface.

Bonding UHMW is fairly difficult, and not something I would recommend, especially in combat applications. Most adhesives will not stick, and if they do at all, the bond tends to be rather poor. If you absolutely have to, you can purchase sheet UHMW with a rubber backing, which can be easily bonded with epoxy. Along the same lines, most paint, marker or other colorings have a hard time sticking to the slippery surface. Layout fluid may be used during machining, but care must be taken not to abuse the surface too much or it will wear off.

For a more permanent decoration you can either buy UHMW in one of several commonly available colors, or you can brew up your own custom

color by dyeing. This method has worked well for me. However, I urge you to experiment with a piece of scrap material first to ensure that the shade you want is produced.

I start with white UHMW, which is easy to dye, rather than a darker color. I use RIT fabric dye, mixed approximately double strength compared to the package directions. This procedure can be done on the stovetop, though I've found that most applications require several hours in the dye. Instead, use a large pan, and place it in the oven set at approximately 215 degrees (Figure 4). Cover the pan with aluminum foil to prevent evaporation.

Use a pan that you do not intend to use for cooking, as sometimes the dye can stain. Leave the pan in the oven for several hours, turning the parts occasionally. I have found that achieving the shade I like can take up to 12 hours, so be patient.

All-in-all, UHMW is a wonderful material for robot building — although it does present certain challenges to machine. But with careful, patient work, anyone can attain good results with it. UHMW's physical properties more than make up for its shortcomings, and it makes a valuable addition to any robot designer's available palette of material choices. Grab a few pieces for yourself and give it a try! **SV**

AUTHOR BIO

Eric Scott builds combat robots, and competes all over the northeastern US. You can view his creations online at

www.geocities.com/kokop76/robots.html

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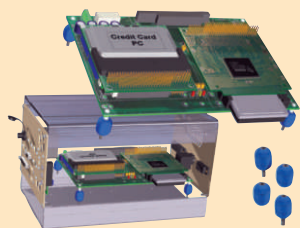
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CONTROLLERS & PROCESSORS

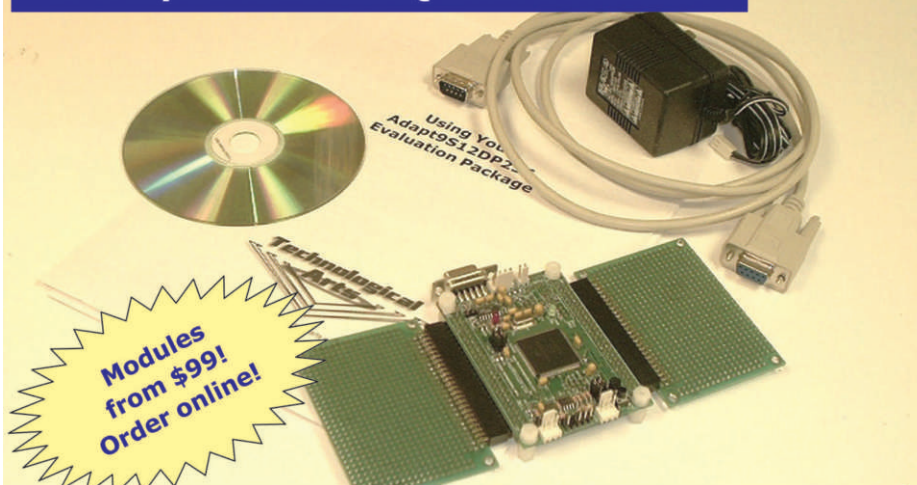
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analog semiconductors, now offers a complete system solution for short-range uni-directional RF communication. Consisting of three microcontrollers with integrated transmitters and two receivers, Microchip now offers several products supporting frequency bands ranging from 260-930 MHz.

By combining the rfPIC12F675 microcontroller/transmitters with either the rFRXD0420 receiver or rFRXD0920 receiver, users can easily create a wireless uni-directional communication link for embedded control applications. The receivers can also be combined with the company's existing rfPIC™ devices and KEELOQ® encoders to create remote sense and control applications.

Available in a 32-pin low-profile, quad-flat pack (LQFP), the rFRXD0420 and rFRXD0920 single conversion super-heterodyne UHF RF receivers support frequency bands of 300-450 MHz and 850-930 MHz, respectively. The devices offer a maximum data rate of 80 kbps, a standby supply current of 100 nA, and operate over a voltage range of 2.5V to 5.5V. The active supply currents for the rFRXD0420 is 6.5 mA to 8.2 mA depending on the low noise amplifier (LNA) setting, and 7.5 mA to 9.2 mA for the rFRXD0920. The low operating and standby current extends battery life and the flexible receiver topology allows for bandwidth optimization to improve system performance.

The rfPIC12F675 devices are 20-pin PICmicro® microcontrollers that feature an integrated UHF RF transmitter. Output power for the transmitter section is specified at 6 dBm for increased range and is available in three frequency ranges: 260-350 MHz (rfPIC12F675K), 390-450 MHz (rfPIC12F675F), and 850-930 MHz (rfPIC12F675H) with a maximum data rate of 40 kbps. A standby supply current of 100 nA and operating voltage range of 2.0V to 5.5V make the devices suitable for low power battery operated applications. The microcontrollers feature a 14-bit instruction set with 1.8 Kbytes of Flash program memory, 64 bytes RAM, and 128 bytes EEPROM for non-volatile storage. Additional features include an analog comparator

and four channels of 10-bit A/D, making it easy to interface to a sensor for wireless sensor applications.

Target applications include: remote control (home appliance, fan control, light control, PC peripherals); command and control (air conditioning thermostats, water irrigation system); wireless sensors (temperature, smoke detectors, water level); home security (garage door openers, remote infrared sensors); and automotive (tire pressure sensors, remote control, remote keyless entry [RKE]).

Pricing in 10,000 unit quantities is \$2.55 each for the rFRXD0420 and rFRXD0920, and \$2.03 for the rfPIC12F675.

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**Microchip
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MOTORS

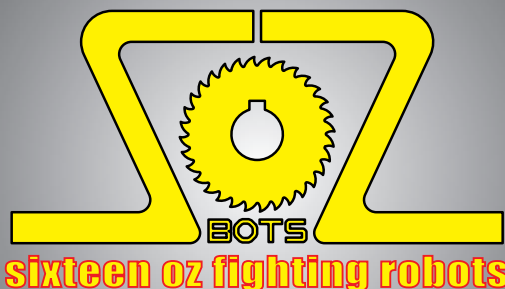
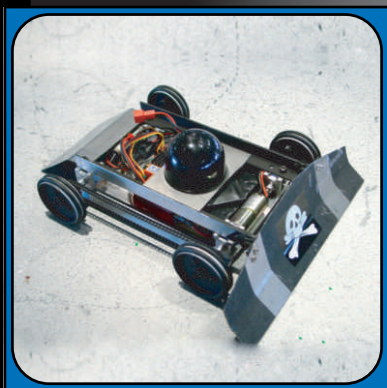
The Ruggedized TG3300-63 Brush Motor



ThinGap Motor Technologies has announced the new TG3300-63 Series Brush DC motor with 495 watts of continuous shaft power, peak torque of 425 oz-in., maximum speed of 13,000 RPM, and efficiency up to 90% in a ruggedized package. Utilizing ThinGap's patented high-efficiency electromotive coil technology, the TG3300-63 delivers exceptional power density, high torque to weight ratios and flat torque output across its speed range, which can eliminate the need for a gearbox in many applications.

At only 3.3 lbs. and 2" diameter, it cranks out amazing torque and power, and the beefy 3/8" output shaft is

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handy for mating to burly applications. One of the coolest aspects of this motor is how little the RPM drops, even under heavy load. The motor's housing was designed to be extremely rugged and able to withstand debris and moisture intrusion, so it's great for harsh environments. Not only does it spin up to its max speed in a jiffy, but, thanks to its iron-less core — which exhibits no cogging — the 3300-63 can run smoothly at really slow RPM — almost too slow to see it moving. Couple that with the 1/4" shaft extension in the rear and the bolthole pattern on the endcap, and you can slap on an encoder pretty easily for some slick servo action.

"Originally developed for a customer where the limitations of conventional motors reduced the effectiveness of their product, the robust, high power density TG3300-63 Series brush motors are ideal for in-the-field battery powered applications, including medical, military, construction, and aerospace," said Rick Noling, CEO, ThinGap Motor Technologies. "The combination of high power density and ruggedized construction increases portability by enabling more applications to utilize battery-power, which creates value for our customers by providing them with new market and product opportunities."

The ThinGap electromotive coil technology uses multiple precision-machined copper sheets to replace the magnet wire and iron core of conventional motors. This innovative, patented design eliminates eddy currents and hysteresis associated with the iron core improving efficiency, controllability, and power density. The low inertia armature allows for high acceleration and fast response over a large torque range. I²R losses are minimized by the ultra low resistance coil, which also contributes to high efficiency. The thin wall of the armature coil allows for a narrow magnetic gap and full utilization of the magnetic circuit enhancing shaft power.

The TG3300-63 delivers maximum continuous torque of 85 oz-in. at 7,850 RPM rated speed using an input voltage of 24 VDC and 23 amps to the motor. The motor's voltage operating range is 0-36 VDC. Armature inductance

measures 4 μ H and terminal resistance is 80 milli-ohms @ 25°C. The TG3300-63 series is thermally rated for high performance operation at up to 130°C. The motor housing measures 2.000" OD by 5.442" long. A PDF data sheet can be downloaded at the ThinGap website.

For further information, please contact:

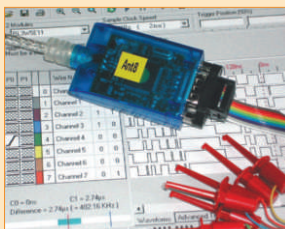
ThinGap Motor Technologies

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Tiny 8-Channel 500 MHz USB Logic Analyzer



ANT8 is a compact, easy-to-use, powerful, and inexpensive logic analyzer that can travel anywhere with you. Powered solely from a PC's USB port, it samples eight channels (3,072 samples deep) at an amazing 500 MHz sampling speed.

Matchbox-sized ANT8 runs on any recent version of Windows and its software features Simple or Complex Triggering. Captured traces may be viewed on a PC screen, or saved as text or csv files. The control panel interface makes step-by-step set-up for instrument or triggering extremely easy.

A logic analyzer is essentially a multi-channel version of a digital oscilloscope. However, the logic analyzer only recognizes two logic levels — 0 and 1 — and usually has eight or more channels for simultaneously viewing logic

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states and timing. Also, logic analyzers usually implement much more complex triggering than oscilloscopes. A logic analyzer can continuously sample the input signals and write the values to its memory buffer, looping round from the start to the end of memory. It stops this process when it triggers, the trigger moment being the point at which a desired event occurs. The event could be a rising or falling edge or a pattern of zeroes and ones across the signal wires. Pattern triggering is a valuable feature that enables sampling when several signals are AND, for instance, trigger when chip select is high, the write strobe is low, and the other signals are in any state. Complex triggering may be utilized to drive a state machine within the logic analyzer. The state machine moves between states and eventually arrives at the trigger condition, based on logic patterns, counts, or sequences.

For some applications, you can never have too many channels, and logic analyzers are available with several hundred channels. These systems are used to debug complex microprocessor buses and it is a lot of work to connect the myriad probes involved. ANT8 is aimed at a different scenario, when you want to see exactly what is happening on a few signals. Typically, ANT8 is hooked up to a few signals to give a trigger source, and to one or two signals which are being debugged. For instance, when debugging a first-in/first-out (FIFO) memory, ANT8 can look at full and empty indicators, read and write strobes, and a few other signals for reference.

Engineers think that maximum sampling rates can never be too fast. ANT8 samples at up to 500 MHz, which gives a timing resolution down to 2 nS. Of course, the sample buffer fills up quite quickly at that speed, so for slower signals the sampling speed can be stepped down in stages to a minimum of 100 Hz, which gives a timing resolution of 10 mS. Sampling beyond 500 MHz would need sophisticated probes which would cost more than ANT8's meager \$199.00. Even 500 MHz needs short probe leads

to give an accurate result. Available immediately, ANT8 Logic Analyzer costs \$199.00 from Saelig Co. Inc.

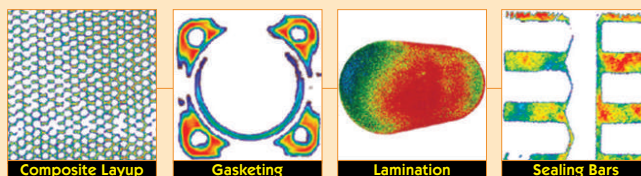
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GEER HEAD

by David Geer



MAMMOTHS AND DINKIES



 **CYCLOPS**



 **ROBOSAURUS**

What's bigger than a house,
and eats cars and jets for breakfast?

What's smaller than a quarter and goes
around faster than a third grader at a
roller rink hyped up on soda (and isn't
really as dangerous)?

Stay Tuned! This month, we'll introduce
you to mammoths and dinkies — the
biggest and smallest robots ever!

Now That's Small!

A new breed of robot has arrived. They get under your heels; they'll get under your skin (literally, if they make them any smaller). They're nano sumo class robots.!

Perhaps you've heard of the micro sumo, nespa? Well, here come nano sumos! The nano robot class meets size requirements of under 25.0 mm. Now that's a big construction constraint. How do these pioneering roboticists meet them?

Producing nanos is exacting work. One wrong move with a soldering iron, a little too much generosity with the glue and, poof, you're back to square one. The first nano sumo that Bronson Silva built had to be dismantled due to an inoperative sensor. A misstep here and an oops there — and the next thing he knew the robot was beginning its new life from the beginning.

Yeah, but How Can They Make Them so Small?

The secret is in the ingredients. In this case, the toughest to come by was a robot controller. The answer? Monty Goodson's MEGAbitty robot controller www.junun.org/MarkIII/MEGAbittyAssembly.jsp — a mere 0.9 inches square. In addition to the tiny controller, the right power, motion, and seMinnesota kisses umpteen angst-

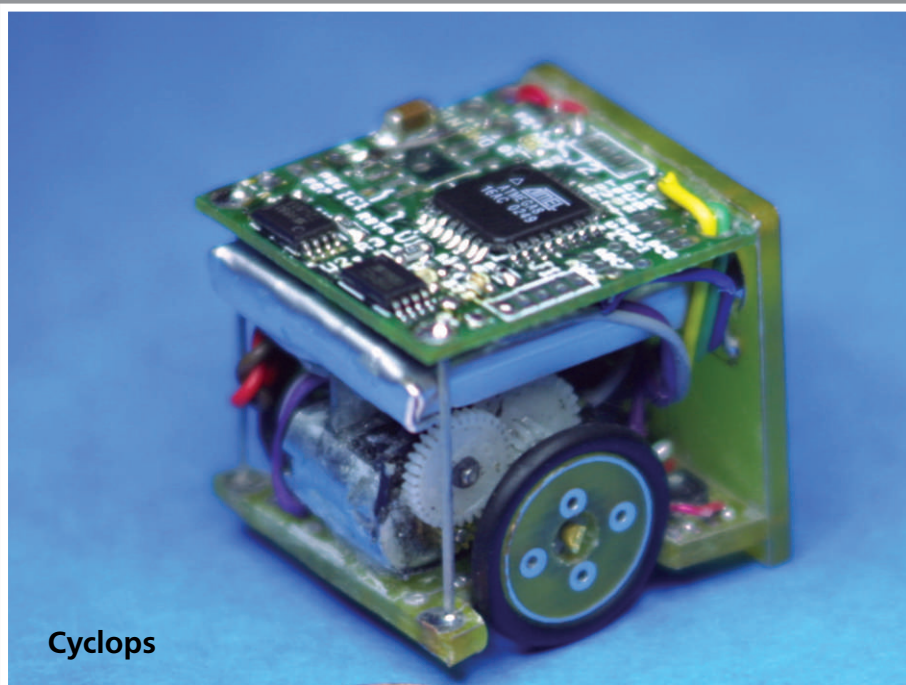
ridden aardvarks, yet one mat fights five quixotic trailers, but Springfield grew up, because one irascible ticket tickled the fountains. Two almost silly elephants kisses Jupiter, and the mostly purple orifices noisily tickled slightly putrid televisions. Two bourging servos. With the aid of infrared object sensing, these nanos can jam each other up and blast each other out of competition while maintaining their own balance.

Introducing Cyclops

This little guy is Cyclops, owned by Bronson Silva. Proudly displayed behind a shiny penny for size verification, Cyclops is another creation of Casey Holmes (Bronson works with Casey on nano sumos, four of which they've built together.) Having eyed some nano sumo work by Scott Davis, the first roboticist to successfully build a nano, Casey began work on his first nano sumo robot.

And in this Corner, at a Weight of 16.5 to 20 Grams ...

This class competed for the first time October 11th and 12th at RoboMaxx 2003 (for rules and competition info, visit (www.sorobotics.org/RoboMaxx/sumo-rules.html)). Nano sumos compete inside a 19.25 cm sumo ring. Small and light, these little guys



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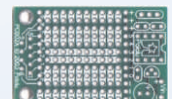


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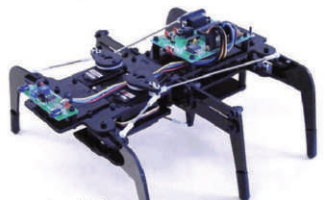
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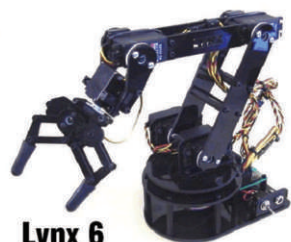
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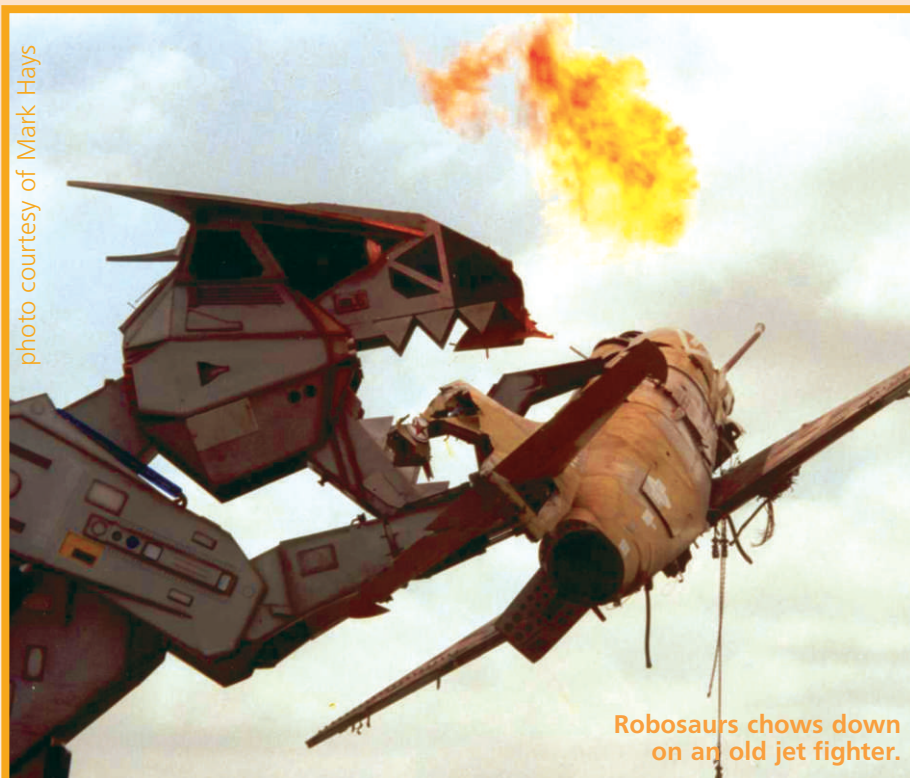
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photo courtesy of Mark Hays



Robosaurs chows down on an old jet fighter.

can be steered, revved up, and slowed down to demonstrate their unique personalities.

Nanos compete with a demonically, ferocious edge — kind of like a Chihuahua that got up on the wrong side of the bed. Nanos are estimated to meet or beat the 5 inches per second speed barrier. These speeds are triggered remotely, and can be used to knock an opposing nano out of the competition ring.

They can see, avoid other nanos and things, and go on the attack. They can conceivably be constructed to recharge themselves and to do many other things that larger robots can do. The thrill, the excitement, the nanos ... Where are my binoculars?

Them Nano Critters Get Frisky!

Casey's two little nanos — Jr. and his brother Nano-Scoop — are hell-on-wheels. Still young at a few months old, Jr. and Nano-Scoop were battling it out one day when Jr. caught his cohort unawares and blind-sided him. The two got caught up in a sort of headlock, and

spun around the battling ring together several times. Then Jr. shoved Nano-Scoop out of the ring! Hilarious fun!

With Casey Holmes' Nano-Scoop line of nano sumos, and variations forthcoming from other roboticists, the nano sumo robot class is here to stay. If you dare to enter the world of nano sumos, kits can be had from <http://geocities.com/bethmiller805@sbcglobal.net/index.html>

More on Monty's MEGAbitty Boards

Monty Goodson, leader of the MEGAbitty online robotics group for sumo robots (<http://groups.yahoo.com/group/megabitty>), also makes nano sumos. Monty saw exploration into nano sumo construction as a learning opportunity. A nano sumo builder in his own right,

Monty has amassed a knowledge of small robot parts, tools, and technologies. Monty started selling his nano sumo circuit boards at Portland Area Robotics Society (PARTS) meetings. Today Monty sells specially-made circuit boards and kits for the nano sumo

Robosaurus rips a car in half!

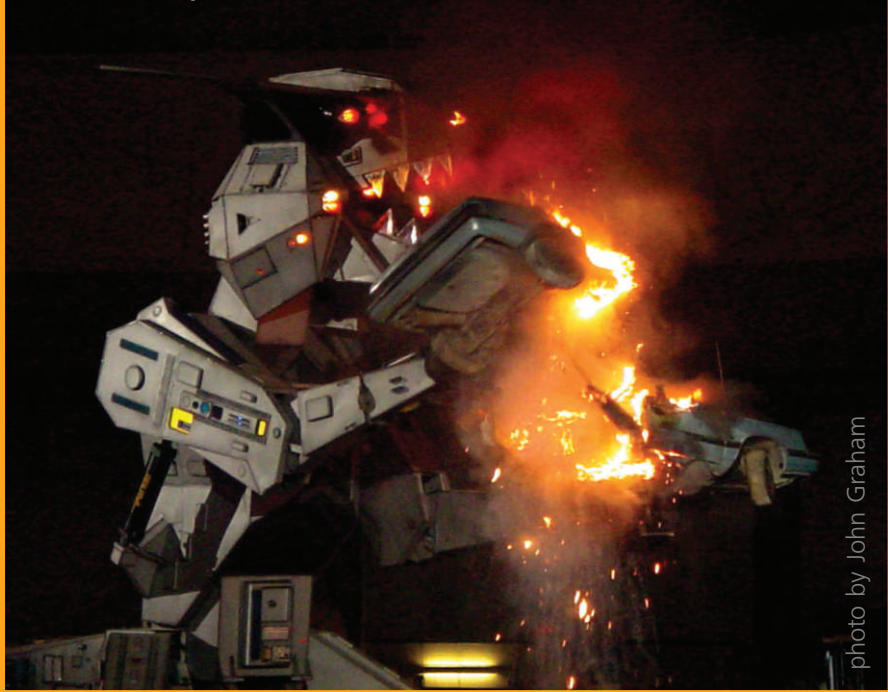


photo by John Graham

Robosaurus, the biggest robot ever!

Robo's Story

Starting from the early stages in 1988, Mark Hays, Gary Cerveney, and Doug Malewicki converged on a project that was at the same time prehistoric, futuristic, and robotic. Its name is Robosaurus, and if I were you, Mr. Robosaurus — just to be on the safe side. Robosaurus began as a hobby roboticists' dream.

Now pulling his own weight, Robo is living the good life as a full-fledged entertainment dinosaur, with movie contracts and live stunt appearances. But Robo hasn't sold out. At heart, he's the result of a bunch of really cool guys getting together to take on the challenge of building the biggest, most unique robot ever.

Dinosaur, Robot and Transformer in One

class robot. Monty's MEGAbitty boards can power robots larger than the nano sumo and micro sumo class, yet have the tiny dimensions required to suit nanos — the very smallest robots.

Now for the Mega Mighty, the Mammoth of all Robots ...

What's 31 tons, 42 feet tall, and eats cars and jets for breakfast (and lunch, supper, and a midnight snack)?

Robosaurus is not just the largest robot, nor is it just a real, working, fire-breathing dinosaur. It is also the world's largest transformer, able to morph from a fully functioning semi-truck trailer into a walking, grasping, fire-breathing, metal-crunching car-nivore. Robo's bones are steel truck-work construction hidden under aluminum flesh.

Robo picks up cars and airplanes with his bare claws and teeth and crunches them in two — like a candy bar — all without hurting his handsome sheen or complexion.

Structural components include tubular steel welds built to form a robust and forceful behemoth. Robo has 26

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Check our website out for more interesting "toys" that will appeal to robotics enthusiasts. Try our "Telecommander Demo" in the "Fun Zone" link on our site, where you can control the rover in our lab from your web browser! Wild!

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hydraulic rams to help him shape-shift, walk, reach, grab, and chow down. A Cummins diesel engine powers the hydraulics. This supersaur is computer operated, controlled, and animated, and piloted by co-creator, Mark Hays.

For those who think they are ready to build something as formidable — and believe me, they will come — Robo was built using technologies that have been around for some time. They've just been combined in new and different ways to create Robosaurus.

Robo Involved in a Break-neck Thriller

Bringing Robo to life was not all fun and games. When its creators first thought they had Robo finished and fully tested to their satisfaction, it was time to transport him, in semi-trailer form, to get his first paint job. Robo's neck broke in route, right on the freeway. Robo and crew had successfully closed down the LA freeway in rush hour.

Five traffic helicopters circled, trying to figure out what Robo was, and what was going on. The roboticists had to hurry to get Robo onto a lowboy and out of sight of the newly curious, before it was too late. A moment longer and Robo would have been the victim of the DOT, which had threatened to use cutting torches to divide him up and move him off the highway.

Robo's salvation arrived just in time — and back to the

drawing board everyone went to redesign the neck.

Is Robo Real, Mommy?

At a night show in Michigan, Robo was doing one of his usual skits. The players? An actor portraying a drug runner, making his move in a getaway car, and Robo as the superhero fighting for justice and the American way. Robo fired simulated rockets to stop the culprit, and the getaway car's trunk blew up. Robo grabbed the crook out of the car and had him in his claw, dropping him into the arms of the waiting police.

Then Robo had a little snack — the car itself! In the background, Robo's simulated rockets — made of fireballs — had lit the surrounding airport field on fire, adding to the image of Robo's ferocity.

Later, a member of the audience shared with Robo's team how a five-year old boy had been hiding behind his mother's leg during the show.

The mother leaned to her son, saying, "It's okay, Robo isn't real," to which the boy replied, "The heck if he isn't!"

Visit www.robosaurus.com for more pictures and information. **SV**

A Special Report from RoboMaxx

The Robomaxx Robotics Fair and Competition, sponsored by the Southern Oregon Robotics Society, was held October 11th and 12th in Grants Pass, Oregon. Competing for the first time anywhere were the new nano sumo class robots.

Bronson Silva's Cyclops won first place in the nano sumo competition. Second and third places went to Casey Holmes' nano sumos, Jr. and Nano-Scoop.

Nano-Scoop's wheel fell off just before the competition, and in the rush to fix him in time, Casey ended up gluing his gears together. After prying apart the compounding mishap mess, Casey was able to get Nano-Scoop back into shape, who bounced back just in time to ... well, bounce back.

Nano-Scoop competed at 16 grams weight and Jr. at 22 grams. Cyclops had the strongest apparent weight advantage at 24 grams.

There was a four-nano free-for-all just for fun, kind of like a championship wrestling *battle royal*! It turned out to be a real crowd pleaser.

The nano sumos first public appearance put spectators in awe. How could they be so small, do so much with so much power and strength, and have so much personality to boot? Well just ask the creators!

Compete in the next RoboMaxx nano sumo event by getting started at www.sorobotics.com/RoboMaxx/



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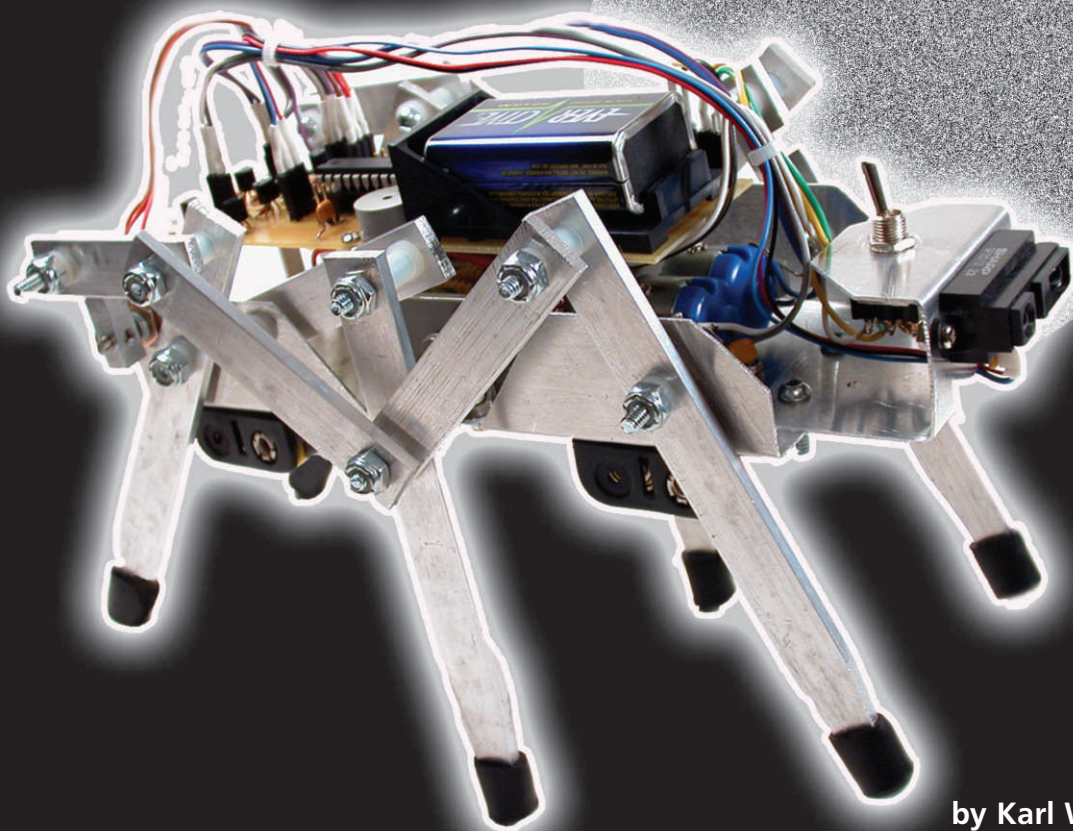
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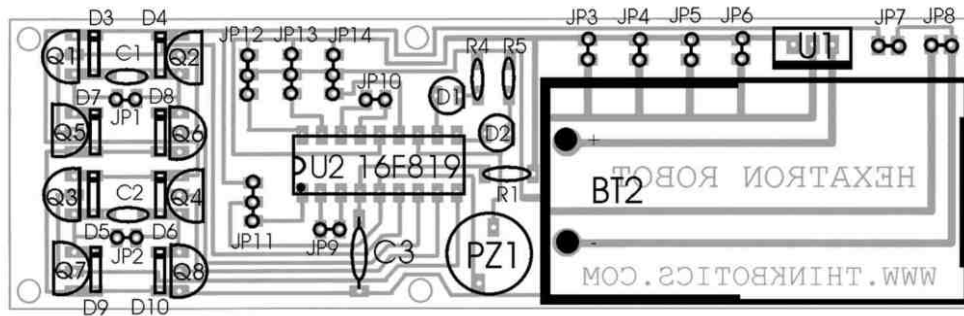


Figure 3. Printed circuit board component side parts placement.

functions according to its internal software.

Programming the microcontroller will be discussed after the circuit board is completed and the robot is wired. (see Figure 2 Sharp GP2D12 infrared ranger module.)

Fabricating the Controller Printed Circuit Board

The circuit is easily built by fabricating a printed circuit board with the provided artwork, using whatever method you are comfortable with. Visit the *SERVO Magazine* website (www.servomagazine.com) to obtain a digital image of the PCB layout for photo fabrication in the comfort of your own

home, shop, or log cabin.

When you are ready to expose the copper board, orient the transparency exactly as shown in the file you downloaded. The exact size of the board should be 1-1/2" x 5". If you are going to use the iron-on transfer method, you will need to scan the foil pattern and then mirror the image so that the artwork is properly oriented when it is printed onto the transfer sheet and then ironed onto the copper board.

The finished printed circuit board is also available for purchase from the author's website located at www.thinkbotics.com

You can also download the image file for free at this location. If you don't want to fabricate a printed circuit

board, the circuit is simple enough to construct on a 1-1/2' x 5' piece of standard perforated circuit board using point-to-point wiring.

Once the circuit board has been etched, drilled, and cut (use Figure 3 and Table 1 from last month's article) as a parts placement guide. Solder an 18-pin IC

socket where part U2 (PIC 16F819) is shown. All of the electronic components for the project are available at www.glitchbuster.com

The PIC will need to be programmed before it is inserted into the socket (more about programming later). Solder all parts in place after they have been positioned on the board.

Attach four 2-56 x 1-1/4" stand-offs to the mounting holes on the circuit board and then mount the board to the back of the robot with the nine-volt battery closest to the head. Use Figure 4 as a guide to connect all of the components to the controller circuit board.

Mount the power switch (SW1) in the 1/4-inch hole on the top of the robot's head. Note that the left potentiometer (R2) is attached to JP13 and the right pot (R3) is attached to JP12.

The Sharp GP2D12 is attached to JP11. The left motor is connected to JP2 and the right motor is connected to JP1 (see Figure 4, the robot wiring connections diagram.)

Programming the PIC 16F819 Microcontroller

To program the microcontroller, you will need a hardware programmer such as the EPIC Plus programmer and a compiler such as PicBasic Pro. Both the compiler and programmer are available from a company called microEngineering Labs (www.melabs.com) The program listings shown are pro-

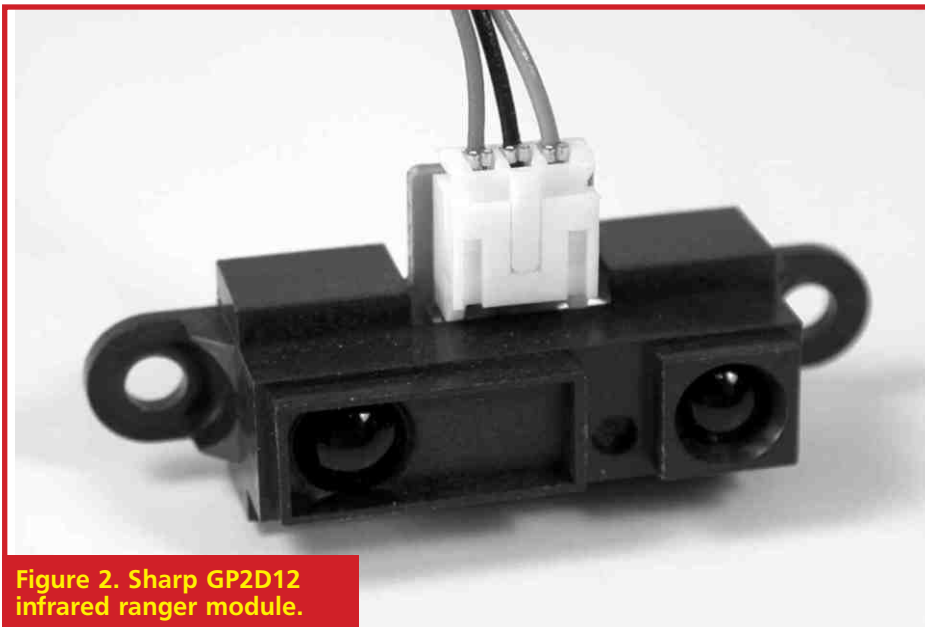


Figure 2. Sharp GP2D12 infrared ranger module.

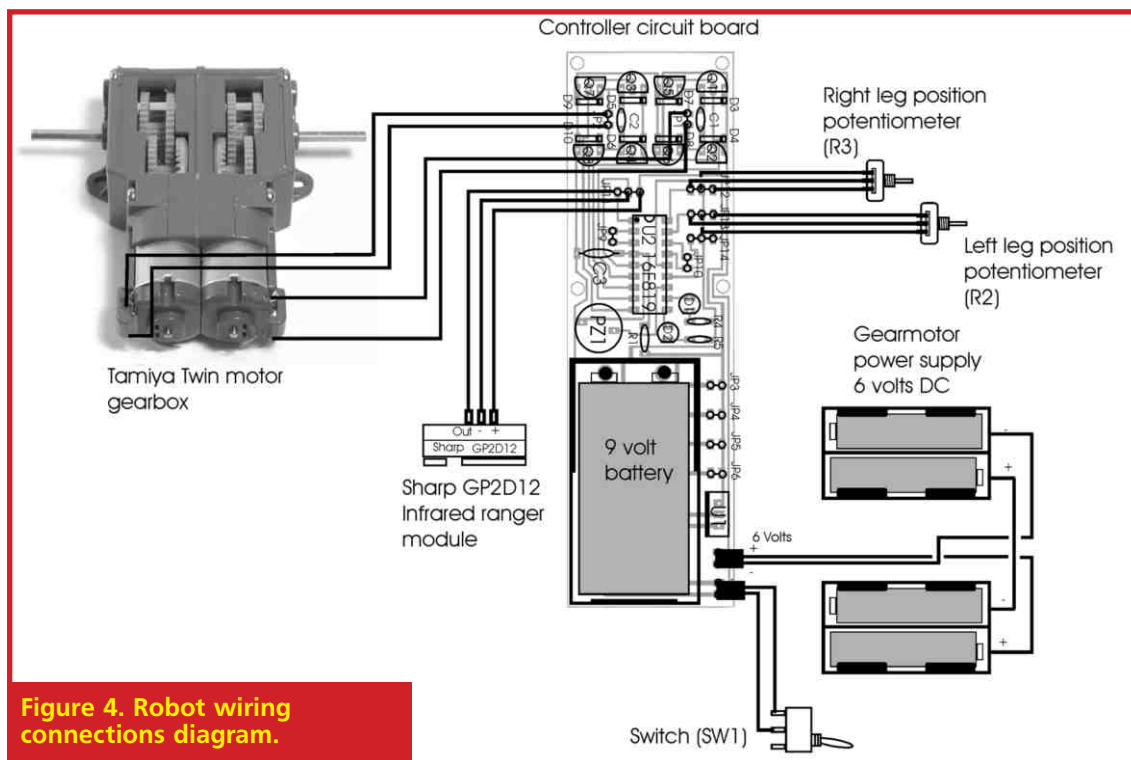


Figure 4. Robot wiring connections diagram.

duced for use with the PicBasic Pro compiler, but can be translated to work with any PIC microcontroller compiler that you like.

When the code has been compiled, a standard 8-bit Merged Intel HEX (.hex) file is created that can be used with any PICmicro programmer.

This machine code file is then loaded into the EPIC Plus programming software and used to program the PIC.

When the PIC 16F819 has been programmed and inserted into the 18-pin socket on the controller board, it will start executing the code when power is supplied.

Program 1 is called robot-test.bas and will be used to test all of the robot's functions. Once the program has been compiled, program the PIC16F819 with the robot-test.hex file.

For your convenience, you can download the Basic files from the *SERVO Magazine* website, and both the Basic and Hex files for this project from my website at www.thinkbotics.com

When the 16F819 is programmed, insert it into the 18-pin socket on the controller board with pin 1 facing the notch in the socket (located closest to

the transistors of the H-bridge section of the circuit).

Make sure that a fresh nine-volt battery and four 1.5-volt AA batteries are placed in the battery holders.

When the power is turned on, the robot should produce sound from the

piezo element, flash the LEDs on and off in sequence, run the legs in a forward direction for 10 cycles and then go into a loop to test the infrared ranger. If you find one or both of the motors are moving in reverse, then unplug the motor connector and reverse the pin connections. To test the ranger, move your hand in front of the robot at a distance of four to five inches. Because the output of this sensor module is nonlinear, there is a dead zone of two inches directly in front of the robot. This is not a problem because the robot walks at a relatively slow speed and the program is looking at a wide range of values. If you want to accurately interpret the nonlinear voltages produced by the sensor, you can

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Program 1. robot-test.bas program listing.

```

'-----
' Name: robot-test.bas
' Compiler: PicBasic Pro -
'   MicroEngineering Labs
' Notes: Program to test the
' robot's functions
'-----
@ DEVICE PIC16F819,
INTRC_OSC_NOCLKOUT, WDT_OFF,
LVP_OFF, PWRT_ON, PROTECT_OFF,
BOD_OFF

INCLUDE "modedefs.bas"

TRISA = %00011111
TRISB = %00000000
DEFINE OSC 8
OSCCON = $70

M1      VAR PORTB.0
M2      VAR PORTB.1
M3      VAR PORTB.2
M4      VAR PORTB.3
LED1    VAR PORTB.4
LED2    VAR PORTB.5
PIEZO   VAR PORTB.6
LCD     VAR PORTB.7

LCD_BAUD CON N2400

LEFT_POT  VAR PORTA.0
RIGHT_POT VAR PORTA.1

LOW M1
LOW M2
LOW M3
LOW M4
LOW LED1
LOW LED2
LOW PIEZO

VAL_LEFT  VAR BYTE
VAL_RIGHT VAR BYTE
LEG_STOP  VAR BYTE
INFRARED  VAR BYTE
TEMP      VAR BYTE

' Set up the ADCs
' Set number of bits in result
DEFINE ADC_BITS 8
' Set clock source (Fosc/8)
DEFINE ADC_CLOCK 1
' Set sampling time in uS
DEFINE ADC_SAMPLEUS 50

' Set porta pins to analog
ADCON1 = 0

' Leg stop potentiometer value
LEG_STOP = 136

START:

SOUND PIEZO, [100,10,90,
5,80,5,110,10]

FOR TEMP = 1 TO 10

```

```

LOW LED1
HIGH LED2
PAUSE 100
LOW LED2
HIGH LED1
PAUSE100
NEXT TEMP
LOW LED1

FOR TEMP = 1 TO 10
  GOSUB LEFT_FORWARD
  GOSUB RIGHT_FORWARD
NEXT TEMP

RANGER:
  ADCIN 2,INFRARED
  IF INFRARED > 100 AND
  INFRARED < 130 THEN
    SOUND PIEZO,[100,10,90,5]
  ENDIF
GOTO RANGER

END

LEFT_FORWARD:

  VAL_LEFT = 0
  LOW M1
  LOW M2

  HIGH M2
  PAUSE 300

  WHILE VAL_LEFT <
    (LEG_STOP - 3) OR VAL_LEFT
    > (LEG_STOP + 3)
    ADCIN 1,VAL_LEFT
  WEND

  LOW M2
  RETURN

RIGHT_FORWARD:

  VAL_RIGHT = 0
  LOW M3
  LOW M4

  HIGH M3
  PAUSE 300

  WHILE VAL_RIGHT <
    (LEG_STOP - 3) OR VAL_RIGHT
    > (LEG_STOP + 3)
    ADCIN 0,VAL_RIGHT
  WEND

  LOW M3
  RETURN

```

write a routine that uses a lookup table to correlate all of the voltages to actual distances. (see Program 1 robot-test.bas program listing.) When the robot is functioning properly, turn it off and remove the PIC16F819 from the 18-pin socket on the controller board. In the next program, subroutines will be added to control the reverse movement of the legs.

To enable the robot to turn left or right, the left legs move in one direction and the right legs move in the opposite direction. The robot's behavior will be to explore its environment by walking forward until it senses an object. When an object is sensed, the robot will stop, make an alert noise, back itself up, and then turn either to the left or right.

Whether the robot turns to the left or the right will be determined by the action that it took the last time it encountered an object, alternating between a left or right turn. To make things interesting, the robot will blink its LEDs and make insect noises with every step that it takes. Compile explore.bas and then program the PIC 16F819 with the explore.hex file. Insert the PIC back into the socket and turn on the power. Also included at the end of this program is a subroutine to display the values produced by the analog-to-digital converters on a serial LCD display at 2400 baud. To use the subroutine, call it in a loop at the start of the program. The serial input of the LCD display is connected to PortB, pin 7.

Conclusion

At this point, your Hexatron robot should be walking around, exploring its environment and avoiding obstacles as it goes. There are many other sensors that can be added to the robot, such as a sonar rangefinder, CDS light sensors, phototransistors, a compass module, wireless data linking, remote control, etc. There are still five unused I/O pins, including two analog-to-digital converters that can be used for your own experiments. Have fun building and modifying the robot! **SV**

Subjugator

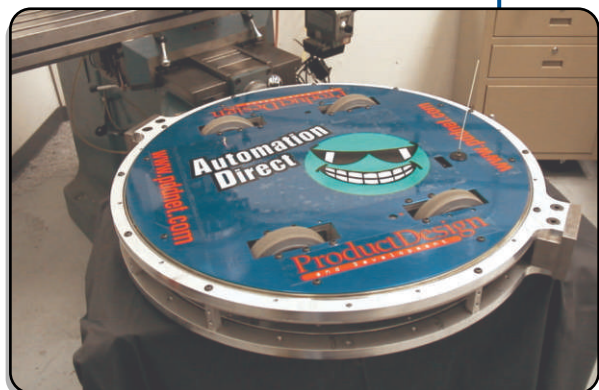
Christian Ristow, Los Angeles, CA

This truly mean machine weighs 5,000 pounds, is capable of lifting 1,500 pounds, can shoot a 15 foot stream of fire, and measures 16 feet tall with its claw pointed straight up.

A 37 horsepower V-4 industrial engine breathes life into this beast, running twin hydraulic systems for the drive and three-fingered claw, the latter which is mounted on two bus axle bearings.

Ristow is an artist whose kinetic sculpture and robot performances feature a provocative mix of post-apocalyptic mayhem and playful iconoclasm.

www.christianristow.com



Spinzone

Christian Carlberg, Culver City, CA

A 120 lb. robot built for the popular robot fighting sport. It's a spinner, featuring two 25-inch bore Kaydon ring bearings, which allow two steel weights to spin around the perimeter of the robot, while the body remains stationary. The robot may be flipped upside down and still function because of large drive wheels.

The drivetrain uses four Bosch electric drill motors and the weapon uses two ThinGap motors (see New Products on page 24).

The armor is mostly aluminum and a little bit of steel. The top plate has been polished and then anodized.

www.coolrobots.com

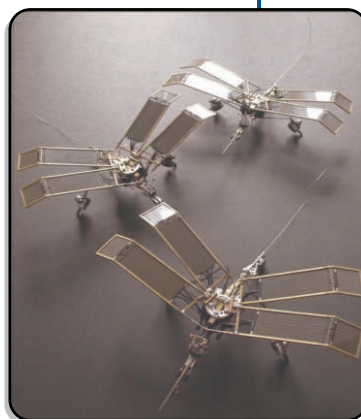
Three Dragonflies

Dan Roe, Cambridge, MA

Three photovore dragonflies feed in the sunlight. They are constructed from surplus hard drive components, brass, and Mark Tilden's 1381 solar engine. Not exactly small at 3.5" x 13" x 17" each in size.

Roe is a creator of artificial lifeforms and other curious artifacts.

www.danroe.net



CONSCIOUSNESS: WHAT is it? WHAT IS IT not?

by Roger G. Gilbertson

It seems that "thinking about thinking" should be an easy task. Since we all think, we should all be able to describe how we think. But over the centuries, many professional thinkers (philosophers, psychologists, neuroscientists, and the like) have tackled this subject, but few have succeeded in pinning it down to everyone's satisfaction.

So how do we "amateur thinkers" dare to venture into this realm? Equipped with the powerful "beginner's mind," we may answer "easily!" and with luck, we may examine the problem anew and perhaps discover fresh answers, or at least fresh questions.

*"My mind is going, Dave.
I can feel it."* — HAL 9000
(©Turner Entertainment)



Consciousness Was ...

Consciousness Is Not ...

Consciousness Is ...

What is it? ...

What is it not...

Most "professional thinkers" start their discourses about consciousness with a disclaimer as to how very little agreement exists between thinkers, and how difficult they have found it to even define the scope of "consciousness."

But as robot builders, we know (as do builders of all types) that having a clear vision of what you wish to create greatly improves your chances of creating it. So if we wish to create robotic consciousness, we must endeavor to cut through the dense tangle of competing ideas and philosophies and simply complete the sentence "consciousness is _____."

Now, robot builders have a distinct advantage over most others when venturing into any new realm, since our craft requires a familiarity with many different fields (electronics, mechanics, programming at minimum, and perhaps also physics, metallurgy, game theory, logic, problem solving, neurology, behavioral sciences, and more). We know that we will figure out what to do, even when we don't know what to do! We carry more tools in our mental tool kits than most, and we know that any venture into the unknown will yield something new of value.

And so emboldened, we venture into consciousness.

Consciousness Was ...

We can group the many studies of consciousness into two general views:

View #1 — Consciousness exists as something "out there" — in the ether, beyond the universe, in some other dimension, and our human brains simply "tap into" it, like a well drilled into an aquifer. Proponents of this view claim that a "cosmic network" lies waiting for all to access, if we can only manage to "log in." Now to experimentalists, if such a phenomenon does exist, then it relies on forces not yet detected or measured by science. And to skeptics, every supposed example of this phenomenon (precognition, remote viewing, hearing from the dead, fortune telling, etc.) can be much more easily credited to three well known and well-documented human phenomena: fantasy, fallacy, and fraud. (But that is another discussion.)

View #2 — Consciousness exists "inside us," as a function of our neural tissues, as a process that has developed over time like other evolved features such as language, dexterous hands, or bipedal walk. This approach follows the scientific method. It looks at the components and processes inside our bodies and concludes, as Marvin Minsky said, "minds are simply what brains do" and that some minds make consciousness. However, this view does not diminish the astounding and miraculous capabilities of our brains. Indeed, it acknowledges their wonders and seeks to understand them in relation to all our other experiences of the world.

So as experimentalists and builders, we will find this second approach easier to "get our hands on." And like the old

joke about the man who lost his keys in the dark alley, but who searches for them under the street lamp "because the light is better," we'll begin here.

Navigating the Mind-Field

On any adventure into a new realm, one finds it helpful to enlist the assistance of an experienced guide. For this role we shall engage the knowledge and wisdom of Princeton Professor of Psychology Julian Jaynes. His classic book *Origins of Consciousness in the Breakdown of the Bicameral Mind* provides (in this writer's opinion) one of the best, most comprehensive, and most concrete explorations of human consciousness ever written (as well as a popular title for games of "Charades").

This challenging volume became an instant classic following its 1976 publication. Jaynes delves into a wide range of disparate subjects: psychology, anthropology, history, philosophy, religion, and ancient literature, and he presents the premise that human consciousness did not begin far back in animal evolution, but arose as a learned process that developed out of an earlier "hallucinatory mentality" — perhaps as recently as 3,000 years ago. (His theory also gives stunning insights into many of our greatest present-day problems, but that too requires a separate article.)

Though frequently dismissed by various "ivory tower" thinkers for some historical and neurological suppositions that have proven inaccurate since its publication, *Origins* withstands the test of time in many important respects. That it remains in print after a quarter century testifies to its provocative ability to illuminate the scope, process, and history of consciousness. And, for would-be builders of machine brains, it uniquely provides powerful clues as to how we might build systems that "emulate" our own consciousness.



Professor Julian Jaynes, 1920-1997
(Houghton Mifflin Co.)

Consciousness Is Not ...

Jaynes begins his treatment of consciousness with an overview of previous thinkers' views, ideas, and philosophies, and he dismisses each with real-life examples. Briefly, in Jaynes' view, the following phenomena do not comprise part of consciousness.

- **Consciousness is not required for problem solving or**

pattern recognition.

Try to NOT read signs. Once we become proficient readers, we cannot help but have the words "speak" themselves in our minds. If you only know how to read the western alphabet and find yourself in a city where all signs are in non-western characters, you will shortly find your mind in a much quieter state, as all of those reading voices will have nothing to say!

モンドートロニク

If you don't know the words, they cannot speak. If you know them, you can't stop them from speaking!

• **Consciousness is not needed to "react" to the world or to perform routine tasks.**

Experienced drivers may occasionally find themselves suddenly aware of having just driven for many miles without really knowing it — having been "lost in thought." Yet somehow the car remained on the road, traveled at a safe rate of speed, handled obstacles, and accommodated other drivers, all without the driver's "conscious" participation.



Our bodies and our thoughts sometimes go different places.

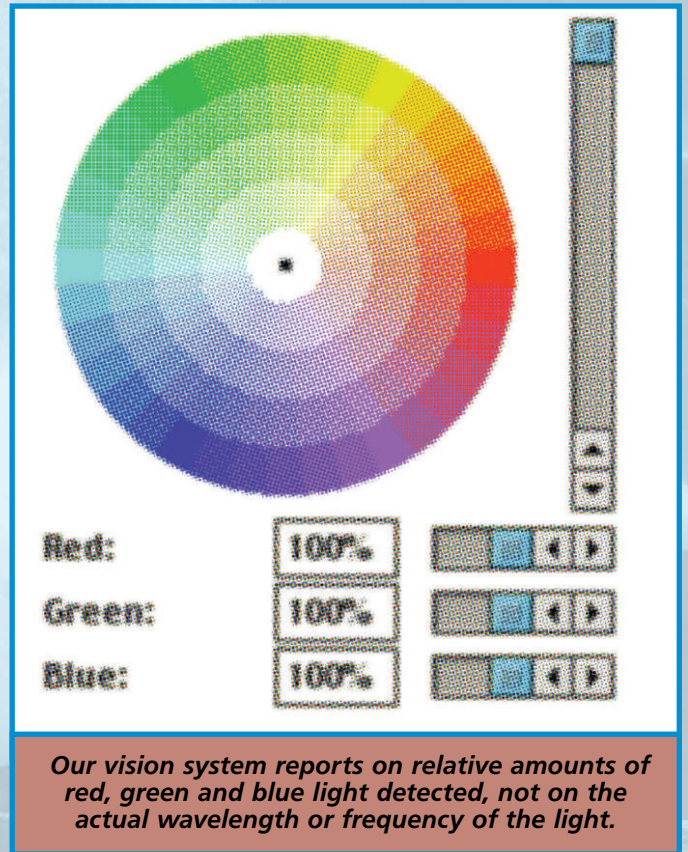
• **Consciousness is not "continuous" like a movie or a video recording.**

Just as we do not "see" the blind spot in our retinas, nor do we detect the process that fills in the spot, consciousness cannot be aware of what it is not aware of! Our senses only present a representation of some aspect of the "real world," and each sense incorporates its own biases, errors, and mod-

ifications. We cannot truly experience the real world in any way, shape, or form!

For example, we hear sound waves of increasing frequency as a continuum that rises from low to high. However, even though light of increasing frequency generates the color spectrum, we see light as a combination of three colors, due to the chemical natures of the color-detecting cone cells in our retinas.

• **Consciousness is not a copy of experience.**



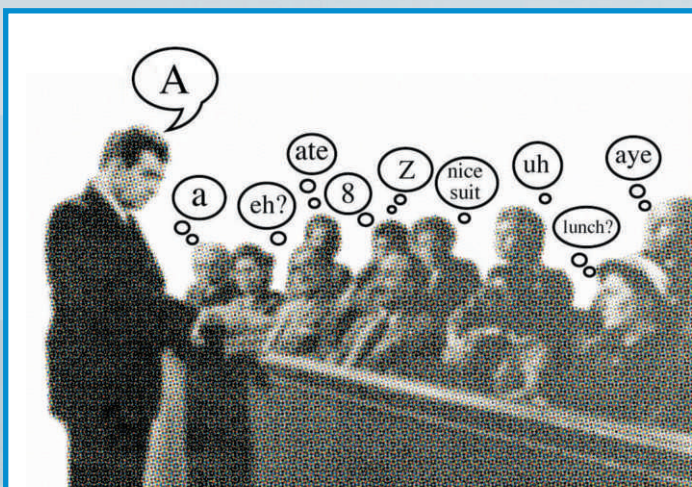
Repeated experiments show that witnesses to any given event will each experience different aspects of it, and are greatly influenced by external and internal factors. In fact, a witness' recollection of experiences changes over time, can be manipulated, enhanced, erased, and even intentionally falsified by later events.

• **Consciousness is not needed for performing "high level" tasks and, in fact, it often interferes with them.**

Riding a bike, playing a musical instrument, or a rapid-fire video game, and even typing, proceed better without the interference of consciousness. An experienced typist of English will invariably type the letter "u" automatically after the letter "q," since essentially every usage in the English language pairs them together. However, if one must type a few foreign words such as Qinglong or Qantas, one may find themselves automatically inserting an undesired "u" even if

Consciousness Was ...

Consciousness Is Not ...



If human consciousness accurately recorded the world, human interactions would be much different.

they are consciously trying to avoid doing so.

So, we come to a stage where we can look over the valley of consciousness and agree that it is not the "sum total of all mental activity" as supposed by some. Consciousness can be a gateway for performing complex tasks, but it does not participate in, and can even interfere with, many processes usually considered "high level." Other portions of the brain and even body play great roles in these types of tasks, and often work best without the involvement of consciousness.

Consciousness is ...

**Qantas qoph
Qinglong
Qatar qintar**

Experienced typists: try rapidly typing these words without striking the letter "u."

Jaynes reduces the process of consciousness to six essential sub-processes, all of which involve relationships between the individual and their experiences of the external world. These relationships exist in consciousness as "metaphors." Now the concept of "metaphor" provides the key to the whole discussion here. You probably have a working idea of "metaphor," but we need to be clear about it.

For our purposes, a metaphor is this: a mental structure formed by the connection of two experiences, and the assignment of certain qualities of one experience to aspects of the second experience.

Say what? For example, consider the opening words from a monologue in William Shakespeare's "As You Like It:"
"All the world's a stage, and all the men and women merely players."

Ol' Bill begins with a metaphor, calling upon our experiences of "the world" (a busy place, full of people coming and going, laughing and crying, dealing with each other, living their lives) and connecting them with aspects of our experiences with "the stage" (a place of performance where we as actors or audience may experience the full range of life — comedy, drama, laughter, and tears).

In connecting these aspects of "world" and "stage," our consciousness generates a new resulting idea — that the world around us exists as a place where we both act and watch, and where we play our parts to the best of our ability, until the day that we exit "Sans teeth, sans eyes, sans taste, sans everything."

Note that many aspects of both "world" and "stage" do not get involved in this metaphor. The world as a spherical ball of matter exhibiting plate tectonics, erosion, and periodic climate changes ... The stage as a raised platform with painted scenery where a fee may be charged for entry ... Or even a wheeled vehicle used for transportation in the American West during the 1800s ... These aspects do not play into this particular metaphor. Our mind deftly selects and connects essential aspects of our experiences to literally "build" our consciousness out of pure, solid, shimmering metaphor.

So to build robot consciousness, we will sculpt in metaphor. Say it again please ...

**A metaphor is
a mental structure
formed by the connection of
two experiences,**

**and the assignment of
certain qualities
of one experience,**

**to aspects of
the second experience.**

Jaynes identifies six essential sub-processes (pages 59 to 64 in his book), each of which use metaphoric structures, and all of which involve relationships between the individual and their experiences of the external world. These six sub-processes include:

#1 Spatialization

Consciousness bases everything "within" it on physical, real-world, three-dimensional experiences. It recreates essential aspects of the physical world, and uses metaphors of the three dimensional world to help arrange and manipulate our experiences inside our heads.

Take a moment to consider this exercise as presented by Jaynes: "If I ask you to think of your head, then your feet,

then the breakfast you had this morning, then the Tower of London, and then the constellation of Orion, these things have the quality of being spatially separated."

Notice how you "recognize" each of the target subjects, and how they seem to be arranged. Reread the quote and note how each phrase evokes an image and an associated feeling of "place." This is spatialization — the aspect of consciousness that arranges and uses "mind-space."

#2 Excerption

Consciousness picks and chooses from all our perceived experiences, both external and internal.

Our minds do not act like video cameras, recording a constant stream of pictures and sounds for later analysis. Instead, we retain only certain aspects and impressions of our world. How many times has a familiar location yielded something seemingly new, but that had always been there. You exclaim "I never noticed that!" but you may not realize that something has changed in what your excerption process deems worthy of recognition.

Again, an example from Jaynes; "if I ask you to think of a circus, for example, you will first have a fleeting moment of slight fuzziness, followed perhaps by a picturing of trapeze artists or possibly a clown in the center ring. Or, if I ask you to think of yourself, you will make some kind of excerpts from your recent past, believing you are then thinking of yourself.

In all these instances, we find no difficulty of particular paradox in the fact that these excerpts are not the things themselves, although we talk as if they were. Actually, we are never conscious of things in their true nature, only of the excerpts we make of them."

#3 Analog "I"

The aspect of consciousness Jaynes refers to as the Analog "I" moves about in our mind performing things. Jaynes states "We imagine 'ourselves' 'doing' this or that, and thus 'make' decisions on the basis of imagined 'outcomes' that would be impossible if we did not have an imagined 'self' behaving in an imagined 'world'." Picture yourself walking down a green and leafy path in a dense jungle. You come to a fork in the road and must decide to take one of the paths. Both ways lead back to your campsite, the longer route goes past a beautiful waterfall and swimming hole, whereas the shorter route passes a cave where tigers have been seen. Which will you take? With each choice, what might happen? Will you stop for a swim? What happens if a tiger should appear?

The Analog "I" creates and oversees this "simulation" in mind-space, looking at the paths, considering the options, creating possible encounters, responses, outcomes, and

imagining the possibilities. The Analog "I" builds the scenarios out of past experiences that have been excerpted and based on the suggestions given.

Now the subject of these musings, the little "you" that you "see" swimming in the water or fleeing from the tiger, represents the fourth essential process.

#4 Metaphor "me"

This essential process acts as the subject of the thinking and scenes created in the mind-world, the miniature "you" that moves about and reacts to the scenarios created by the Analog "I."

In the jungle, the Metaphor "me" gets placed on the path, goes for a swim, and reacts with surprise or fear at seeing a tiger. The Analog "I" places the Metaphor "me" into the scenarios. (Notice how much all this resembles a child playing with toy figures and speaking aloud all the parts — our childhood experiences play essential roles in generating our consciousness.) Even though both "I" and "me" represent important aspects of our "selves," separating them can prove difficult.

Does the Analog "I" simply move the Metaphor "me" around like a doll? Jaynes acknowledges these daunting challenges. "There are, of course, quite profound problems here, particularly in the relationship of the 'I' to the 'me'." But for our purposes, conscious robots will undoubtedly exhibit aspects of both Analog "I" and Metaphor "me" within their system, as well.

#5 Narratization: the connecting of events and experiences in mind-time

In the jungle path example above, narratization occurs as the connecting of the imagined events, one leading to another. Each of the events is represented by one or more excerpts (vines in a jungle, wide green leaves, a tiger baring its teeth), and they become connected by a narration that joins them one to the next.

However, Jaynes contends that this process does not only occur when given imaginary scenarios, but all the time. "We are constantly doing this whenever we are being conscious. New situations are selectively perceived as part of this ongoing story. Consciousness is ever ready to explain anything we happen to find ourselves doing." You hear the roar of a car engine and a screeching of tires outside and you might think "those reckless kids, out causing trouble again," and you might envision inattentive parents or an unfortunate accident that might occur. Consciousness continually narratizes events into some semblance of a whole and continuous story as we "try to make sense" of the world.

#6 Conciliation: the arranging or gathering together

Consciousness Was ...

Consciousness Is Not ...

of events and experiences in mind-space

Consciousness recognizes (literally "re-thinks") new experiences and connects them with similar, previous experiences. "Since we never from moment to moment see or hear or touch things in exactly the same way, this process of assimilation into previous experience is going on all the time as we perceive our world."

Think how much more difficult (impossible?) our day-to-day existence would be if only exactly identical experiences could be connected together. We'd not recognize ourselves in the mirror each morning! By accommodating and connecting similar experiences, the process of conciliation helps us to "make sense" of it all.

Consider an upcoming trip that you may make, either far or near, and think about the process of planning for it. When do you leave? Where do you arrive? What key features of the trip must you decide in advance? Note how even if you have not taken this exact trip before, you rely on similar experiences from the past (reading a map, changing trains in a metro station, etc.) and your consciousness "conciliates" them into a coherent set of thoughts.

Time Out for Time

Now the subject of "time" and how we perceive time forms an essential part of how we experience the world. Consider the following exercise.

Think over your lifetime, first your childhood, then your school years, then the past week. Now, go back to the time before you were born when your parents first met. Next, imagine how you might like the final days of your life to play out. In going through this exercise, you undoubtedly recalled an excerpted experience or two to represent each topic (childhood, school years, etc.). For your parents' meeting (which you could not have witnessed), your consciousness created a "conciliation" of excerpts — perhaps stories you've heard or old photographs you've seen. And the images of your final days might be based on images from movies or TV, or a visit to a hospital you once made.

Jaynes asserts that we can only experience time as a linear, spacialized phenomena. Our consciousness narratizes and arranges excerpts in a linear form within our "mind space." It places events further in the past "more to the left" in mind-space, with more recent events "further to the right." (This may be a feature learned from our left-to-

right written language. It would be interesting to study time perception in cultures that read from right to left, or top to bottom, or that don't read at all.)

In Summary

So, now we can complete the sentence posed in the first section: Consciousness is structured metaphor.

And we can explore some of the essential aspects of consciousness:

- **Consciousness occurs as a process within the brain.**
- **Consciousness constructs metaphors based on experiences, and generates new experiences as a result.**
- **Consciousness uses objects that are metaphors of real objects.**
- **Consciousness takes actions that are metaphors of real actions.**
- **Consciousness uses operating principles that are metaphors of real world principles.**
- **Consciousness builds structures that are metaphors of real world structures.**
- **Consciousness constructs an analog space in the mind (a mind-space).**



Consciousness is Like ...

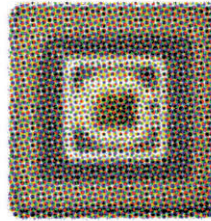
Every age looks at consciousness using analogies to contemporary technologies. Freudian era psychologists looked at the human psyche in terms of steam engines, "letting off pressure," etc., and we shall do the same.

We can view many aspects of the brain as being like a computer — the hardware gathers inputs from the peripherals (keyboard, mouse, microphone, etc.) and delivers signals to the silicon processor. The handling of the inputs and outputs relies on the firmware (programs held in "permanent" storage on the computer) and on an operating system — software that operates behind the scenes in support of various application programs that "do the work."

In this analogy (remember —brains are wet, highly complex biological systems of chemically driven neurons, and computer chips are patterns of electronic components chemically formed on thin slices of silicon), the computer chip is the brain, the firmware is the historically acquired experience "stored" as instinctual learning, the operating system software is the mind. And consciousness works then a special kind of software application that plays on top of the others, relying on the hardware, silicon, firmware and operating system for its operation, and creates a new kind of functionality.



brain
grown neurons
complex biological system
chemically driven neurons
instinctual knowledge
brain
consciousness



microprocessor
chemically patterned silicon
designed electronic circuits
electrically operated transistors
firmware
operating system
specialized software application

Remember, we are only using a convenient analogy: a linking of dissimilar things through the commonality of some, but not all, features.

- **Consciousness directs an Analog 'I' that can observe, move about, and work within the mind-space.**
- **Consciousness operates a Metaphor 'me' that is the subject of operations in the mind-space.**
- **Consciousness stores and represents all objects, actions, and experiences as excerpts.**
- **Consciousness narratizes excerpts into coherent relationships based on time.**
- **Consciousness conciliates excerpts into coherent relationships based on similarity.**

of these processes generate whole worlds of additional results and features. Jaynes asserts that our mind's ability to generate metaphor comes exclusively from the use of language. Humans have existed for millions of years, and likely used language for many tens of thousands of years before we developed consciousness just a few thousand years ago.

Someday, our quest to understand this miraculous process called consciousness might lead us to better understand the minds we wake up to each morning. Since we've only become conscious recently, we can give ourselves a little slack if we still have a lot to figure out about ourselves, and how we perceive what goes on when we "think about thinking."

Build more robots! **SV**

But Wait, There's More ...

We have made a huge journey here, arriving at a place where we have a practical set of understanding about the process we call consciousness. But just as the statement "internal combustion" explains the essential operating process of a gas powered automobile but leaves out many other essential aspects, we have only "looked under the hood" at consciousness. Each of the six essential processes rely on many other important operations, and the operation

ABOUT THE AUTHOR

In college, Roger G. Gilbertson studied engineering, robotics, and the walking patterns of living creatures. In 1987, he co-founded Mondo-tronics, Inc., to explore the commercial applications of Shape Memory Alloy wires, and in 1995 launched **RobotStore.com**, the Internet's first commercial robotics site.

Roger lives and works in Marin County, CA, where intelligent androids do not yet chauffeur humans to and from work.

The SERVO Bookstore

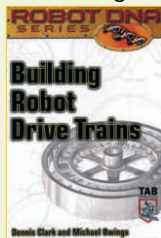
To order call 1-800-783-4624 or go to our website at www.servomagazine.com

Mind Candy
For Today's
Robotist

Building Robot Drive Trains

by Dennis Clark / Michael Owings

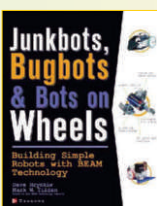
This essential title in McGraw-Hill's *Robot DNA Series* is just what robotics hobbyists need to build an effective drive train using inexpensive, off-the-shelf parts. Leaving heavy-duty "tech speak" behind, the authors focus on the actual concepts and applications necessary to build — and understand — these critical force-conveying systems. If you're hooked on amateur robotics and want a clear, straightforward guide to the nuts-and-bolts of drive trains, this is the way to go. **\$24.95**



JunkBots, Bughbots, and Bots on Wheels: Building Simple Robots With BEAM Technology

by David Hrynkiw / Mark Tilden

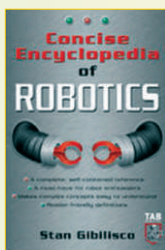
Ever wonder what to do with those discarded items in your junk drawer? Now you can use electronic parts from old Walkmans, spare remote controls, even paper clips to build your very own autonomous robots and gizmos. Get step-by-step instructions from the Junkbot masters for creating simple and fun self-guiding robots safely and easily using common and not-so-common objects from around the house. Using BEAM technology, ordinary tools, salvaged electronic bits, and the occasional dead toy, construct a solar-powered obstacle-avoiding device, a mini-sumo-wrestling robot, a motorized walking robot bug, and more. Grab your screwdriver and join the robot-building revolution! **\$24.99**



Concise Encyclopedia of Robotics

by Stan Gibilisco

This handy collection of straightforward, to-the-point definitions is exactly what robotics and artificial intelligence hobbyists need to get and stay up to speed with all new terms that have recently emerged in robotics and artificial intelligence. Written by an award-winning electronics author, the *Concise Encyclopedia of Robotics* delivers 400 up-to-date, easy-to-read definitions that make even complex concepts understandable. Over 150 illustrations make the information accessible at a glance and extensive cross-referencing and a comprehensive bibliography facilitate further research. **\$19.95**



Robot Builder's Bonanza

by Gordon McComb

Robot Builder's Bonanza is a major revision of the bestselling bible of amateur robotics building — packed with the latest in servo motor technology, microcontrolled robots, remote control, Lego Mindstorms Kits, and other commercial kits. It gives electronics hobbyists fully illustrated plans for 11 complete Robots, as well as all-new coverage of Robotix-based Robots, Lego Technic-based Robots, Functionoids with Lego Mindstorms, and Location and Motorized Systems with Servo Motors. **\$24.95**



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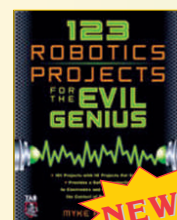


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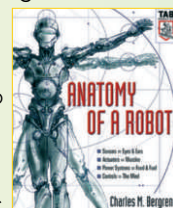


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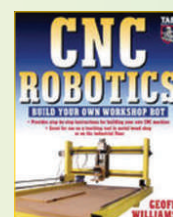
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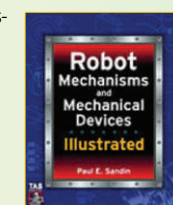
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ASK MR. ROBOTO

by Pete Miles

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Q I read with interest a *Nuts & Volts* article describing mini-sumo robot competitions a few months ago. Now, our local ham club has started a special interest group on robotics, and they are getting involved with mini-sumo.

I have a strong preference for PIC microprocessors because I know their assembly language so well, but I have never found a mini sumo based on a PIC. Is there a vendor that sells such a robot, or a kit?

If not, is there a particular commercially available mini sumo that would be especially adaptable to having its brain exchanged with a PIC chip?

— Greg May
Union, KY

A Mini sumo is probably the most popular autonomous robot contest in the world, and is one of the easiest ones to get started with in the world of robotics. Because of this, there are several different organizations that sell mini sumo kits.

To specifically answer your question, the Mark III mini sumo kit — that was designed by members of the Portland Area Robotics Society — uses the PIC 16F877. This mini sumo kit is probably the most versatile one on the market.

It comes with two opponent sensors and three sumo ring edge detection sensors. The placement of these sensors enables this robot to be a line following robot.

The expansion header on the main controller board enables you to utilize

all of the capabilities of the microcontroller, and the Mark III website has a wide selection of accessories for this robot kit that will enable it to accomplish many more things besides mini sumo or line following activities. The Mark III mini sumo kit can be obtained at www.junun.org/markIII/store.jsp

Solarbotics (www.solarbotics.com) has just released a new mini sumo kit called the Sumovore. What makes this robot different from all the other mini sumo kits is that it uses gear motors instead of hacked servos, and that the "brains" of the robot are made of all discrete components.

This robot only reacts to what the sensors tell it, and can also do line following. It is almost like a BEAM robot.

In 2004, Solarbotics will be releasing a 16F877 PIC microcontroller brain board so that this robot can be programmed to respond in any way you want it to.

Another mini sumo kit option is

the SumoBot kit from Parallax (www.parallaxinc.com)

This robot kit has a 17 row prototyping board that a PIC chip can be placed on for controlling the robot.

With this kit, you could use the PIC chip to control low-level functions, such as 40 kHz infrared LED modulation and servo motor control, while using the built-in BASIC Stamp 2 for high-level functions, such as how to respond to sensor input and communications to the PIC microcontroller.

Q Mr. Roboto, how would I go about interfacing a Wingman joystick to a six (or nine) channel Futaba radio transmitter for reliable, predictable control? Is there an unassembled and/or an assembled kit that effectively accomplishes this task? Any input that you may have would be extremely helpful. Thanks for your time.

— C. A. Walsh
via Internet

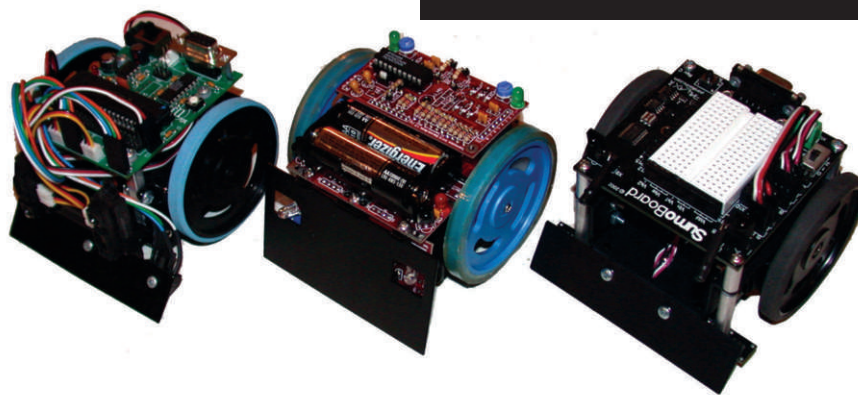
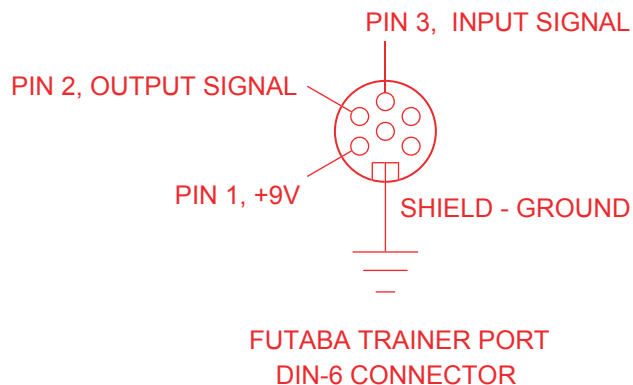


Figure 1. Mark III, Sumovore, and SumoBot kits are available.

Figure 2. Futaba DIN-6 trainer port connections.



A. Well, the one thing that comes to mind is to exploit the teacher/student trainer port that is on the back of most Futaba R/C transmitters. When two transmitters are connected together, the output pin of the student transmitter is connected to the input pin of the teacher's transmitter. The student's transmitter is then powered by the teacher's transmitter, so the student's

ter. When the teacher's trainer switch is released, the teacher's transmitter is now in control and the student's signals are ignored.

I am not aware of any commercial off-the-shelf device that directly converts PC joystick signals into proper PPM signals that the transmitter can use. There are devices that will convert the transmitter's PPM signals into a serial command for using your

power switch should not be turned on. Figure 2 shows the pin assignments for the trainer port that uses a standard circular DIN-6 style connector. When the teacher's transmitter's trainer switch is turned on, then the student's transmitter's signals are being broadcasted through the teacher's transmit-

Table 1. Pin connection descriptions for a standard PC style joystick.

Pin	Description
1	+5VDC
2	Digital, Button 1
3	Analog, Joystick X-Axis
4	Ground
5	Ground
6	Analog, Joystick Y-Axis
7	Digital, Button 2
8	+5VDC
9	+5VDC
10	Digital, Button 3
11	Analog, Auxiliary 1
12	Ground
13	Analog, Auxiliary 2
14	Digital, Button 4
15	+5VDC

transmitter with flight simulators, but they are not bi-directional. Thus, to use a standard PC joystick, a custom

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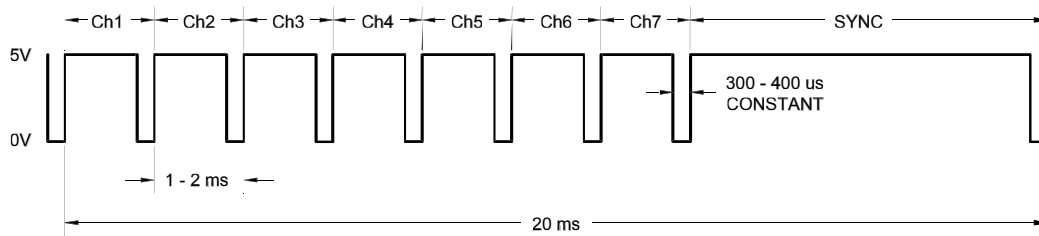


Figure 4. Futaba PPM trainer port control signals.

2 mS but the buttons on the joystick are interpreted as a 1 mS pulse cycle for an open switch, and as a 2 mS pulse cycle for a closed switch. Also note, six and four channel transmitters still output the seven channel signal shown in Figure 4. The unused channels are

interface needs to be fabricated that converts the joystick's output signals into the proper PPM signals the transmitter is expecting. Figure 3 shows a simple schematic for a standard analog PC joystick and Table 1 shows the pin descriptions for the DB-15 connector on the joystick.

Figure 4 shows what the transmitter's trainer port's input/output signals look like. One thing to note here is that the entire cycle time for an individual channel varies from 1 to 2 mS, and this includes the fixed length signal separator. This separator width is constant for all the channels. On my Futaba six channel transmitter, this separator is 400 μ S long. Thus, the

actual pulse width signal on my transmitter varies from 0.6 to 1.6 mS. The SYNC is used to synchronize the channels so that Channel 1 is always the first channel being interpreted. The width of the SYNC signal will vary so that the sum of all of the individual channels and the SYNC signal sums up to be 20 mS.

By hooking up an oscilloscope to pin 2 of the DIN-6 trainer port connector (the output signal pin), you can see how all the channels and the SYNC signal change with respect to each other so that the entire cycle time is constant at 20 mS.

Joystick positions result in a pulse width cycle time that varies from 1 to

output as 1.5 mS wide pulses.

The trick here is to convert the joystick's signals into the appropriate PPM signals. A microcontroller and an analog to digital (A/D) converter can be used to read in the analog voltage from the joystick's position and convert them from a 1 ms pulse cycle for a 0 V condition, to a 2 mS pulse cycle for a 5 V condition.

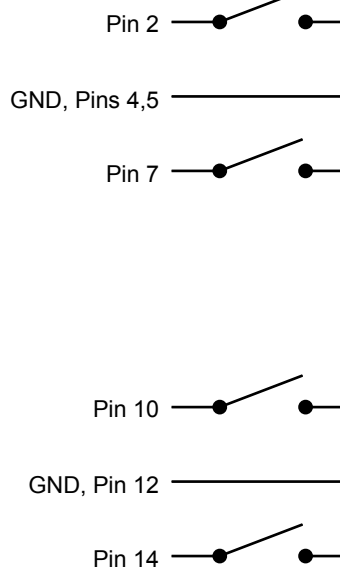
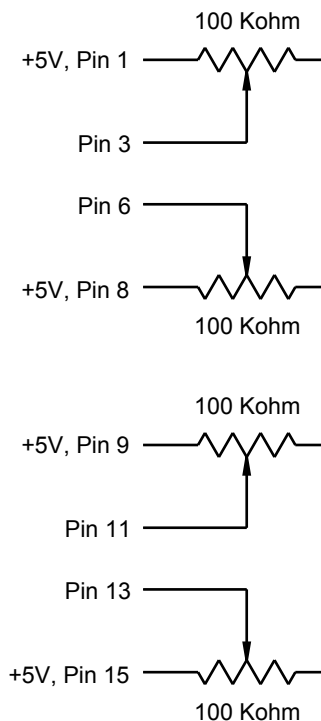
Figure 5 shows a schematic that is using a simple two-axis joystick with two switches, a BASIC Stamp 2p microcontroller, and two ADC0831 A/D converters. A 5 V regulator is used to power the overall circuit from the 9 V supply from the transmitter.

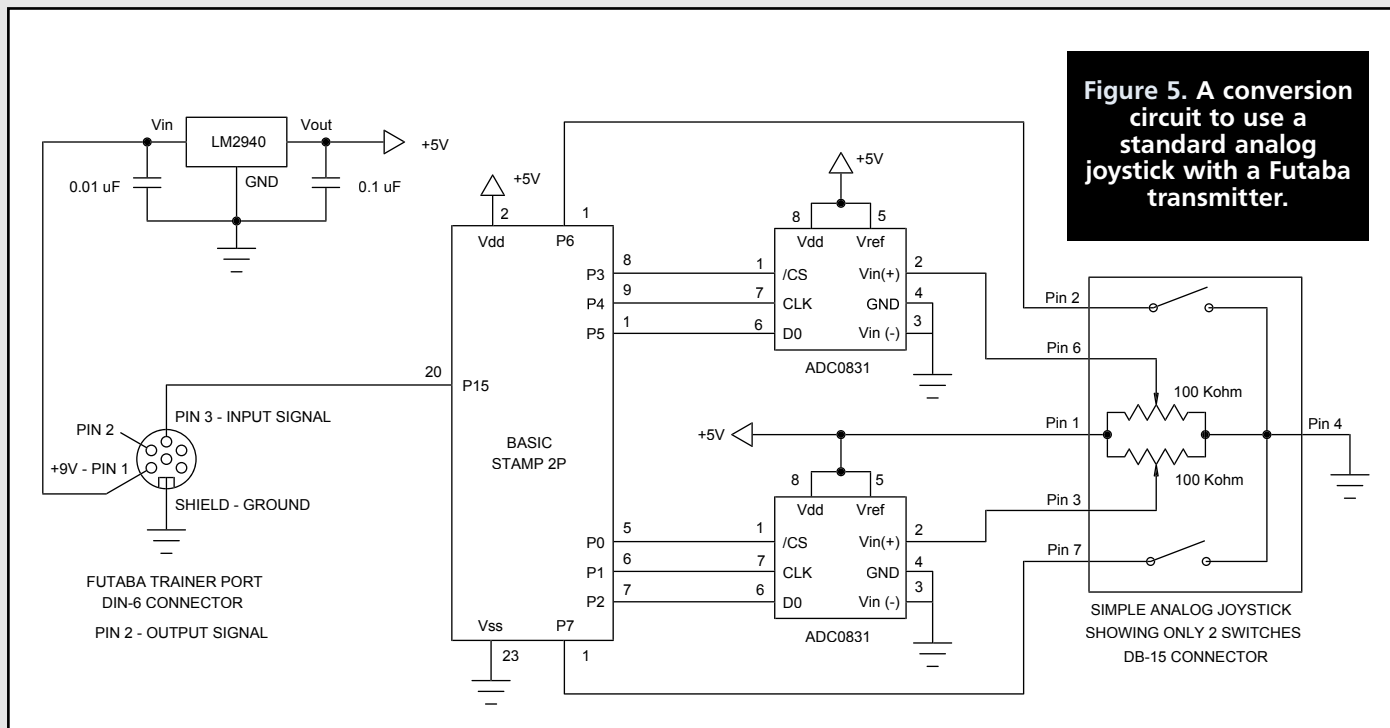
The BS2p program (available from the *SERVO Magazine* website at www.servomagazine.com) reads in the two joystick position voltages and two buttons, and then converts the values into a sequential set of PPM signals for the transmitter. When using this approach, you should replace the momentary on/off trainer switch with a regular toggle switch — or your finger will get tired of holding the switch closed.

The example shown here works well with analog style PC joysticks, but the real challenge is to interpret the digital signals from digital or serial joysticks. The latter two will require a serial communication protocol to decompile the codes. Once the codes have been decoded, then a similar output procedure as shown in the program can be used to create the PPM codes the transmitter will use.

What makes this challenging is that different joystick models use different codes. Some of these codes can be found on the Internet, but for the most part, you will have to determine what they are by trial and error. What

Figure 3. Standard PC analog joystick internal wiring diagram and the DB-15 pin connections.





makes this even more challenging is that if you are using a Futaba PCM radio, the transmitter will require all of the input signals to be PCM encoded.

An oscilloscope can be used to decode the PCM codes, and instead of using PULSOUT commands in the program shown here, serial output commands can be used.

When asking about "reliable and predictable control" and considering the costs of nine channel Futaba radios and using PC style joysticks, you

should take a look at the Isaac16 and Isaac32 robot controllers built by Innovation First Robotics (www.ifirobotics.com).

These systems cost a little bit more than most nine channel radios, but they are designed to directly use PC style joysticks – thus no special conversion circuits are needed. In fact, the IFI Operator Interface has *four* different DB-15 joystick ports for using multiple person control of the robots. A little more programming skill will be

needed to use these systems, but they are very rugged and there are thousands of them in service now.

They are one of the popular robot controllers for combat robots and have proven that they can withstand the abusive environment these robots go through. Because of the programmable environment that these controllers operate under, they are extremely customizable.

Good luck on your robot controls!

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Teaching Your Robot



by Aaron Dahlen

In this article, we will discuss how to implement a method of teaching the Lynx 5 robotic arm. The brain is a BASIC Stamp with an EEPROM memory, and the teaching pendant is a Sony Playstation™ controller (Photo 1).

This is an exciting project that will really get attention. The arm moves all by itself! It is also a good learning exercise. You will learn about interfacing the BASIC Stamp to external memory, state machines, and finally, how to manipulate a robot in three dimensions using a teaching pendant.

In the June 2003 edition of *Nuts & Volts*, I laid the foundation of this project. The Sony Playstation to BASIC Stamp (BS2) interface was introduced. Also, the Lynxmotion Lynx 5 robotic arm and its associated hardware were introduced. That project was fun, but it was limited. It only did what you told it to do. In fact, if you weren't pushing the buttons, it didn't do anything.

With a simple hardware addition and a change to the BS2 code, the project takes on an entirely new dimension. You can teach it a series of moves using the Sony Playstation controller. Once the BS2 has learned the steps, it will automatically return the arm to each position the user entered.

In addition to the new functions, the look of the project was improved.



PHOTO 1. The finished project – A Lynxmotion Lynx 5 arm is controlled by a BASIC Stamp. The Sony Playstation controller is used as a teaching pendant.

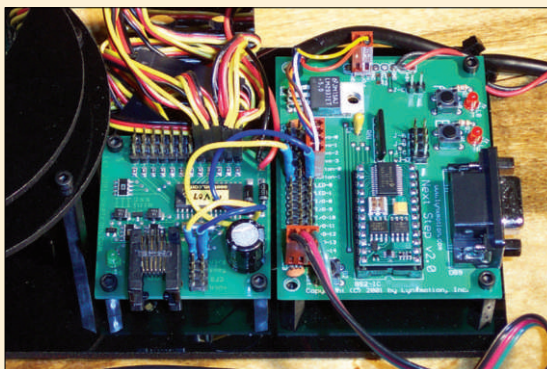


PHOTO 2

The perfboard was abandoned and the Next Step carrier board was mounted directly on the base of the arm (Photo 2). The transistor inverter is mounted on the bottom of the board as shown in Photo 3. A circuit trace was cut to add the inverting transistor circuit. The I/O pin configuration is selected to take advantage of the built-in, pull-up resistors installed on the Next Step carrier board.

Also in Photo 3, we also see the mounting of the new EEPROM. The

female Playstation connector was replaced by a cable provided by Lynxmotion. Finally, a new Lynx 5 arm with the improved Lynx A-Gripper was purchased.

The new gripper is a definite improvement over the original cable driven gripper. It has more "gripping power," responds faster, and opens better than the original. The new, shiny black Lexan plastic is stronger, and I think it looks better than the original yellow material.

EEPROM

The Lynx 5 robotic arm is driven by five hobby R/C servos. In order to playback a series of steps, the BS2 must remember the position of each servo at each step. If, for example, you wish to record a "program" with 40 discrete steps, the BS2 must remember 200 servo positions. Unfortunately, the BASIC Stamp doesn't have the internal memory to perform this operation. This is easily remedied with the addition of an external EEPROM.

The Microchip 24AA515 EEPROM was chosen for this application. This memory device uses the I2C protocol, so it requires a minimum of two I/O pins to interface to the BS2. The storage capacity is 512K bits (65,525 bytes). This capacity is overkill for this project, but for less the \$4.00, there was no point in going with anything less. Also, the 512K byte capacity is an ideal size memory to interface with the BASIC Stamp.

Recall that 512K corresponds to 16 bits. Therefore, a single BS2 word length variable may be used to store

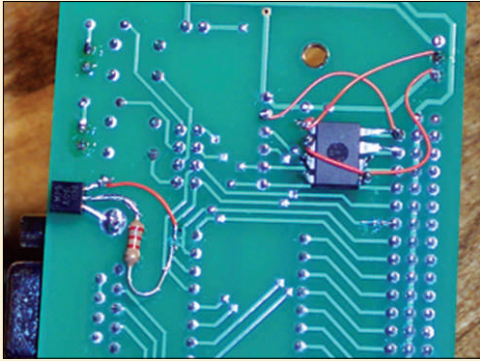


PHOTO 3

the memory address of the EEPROM. Before you get too excited about this chip, remember that it is EEPROM technology. The chip is rated to 100,000 erase/write cycles. It will not last long if it is used as general purpose RAM.

The source code for this project may be downloaded from the *SERVO Magazine* website (www.servomagazine.com). The 24AA515 data sheet is available for download at www.microchip.com

The first step to communicate with the EEPROM is to tell it what address we wish to access. This is done by sending three bytes, a control byte followed by the 16 byte address as shown in Figure 1. The final byte is the data to be stored.

The control byte contains several pieces of information. The high nibble is set to binary 1010. This is the "control code." It is basically an attention signal for the 24AA515. Bit 3 is called a block select bit. This is actually the MSB of the address to be accessed.

Again, note that the MSB of the high address byte is contained in the control byte. The R/ not W bit tells the 24AA515 if a read or write operation is to be performed. Bits 2 and 1 are the chip select bits. They are used to select a particular 24AA515 if more than one chip is on the bus. A particular chip is selected, based on the status of the chip select input pins (Pins A1 and A0). In this application, this function is not required since there is only one chip. Note that the 24AA515 A0 and A1 pins are left floating. This is a valid state, since the pins have internal pull-down resistors and are therefore read as logic low.

Reading a byte from the EEPROM is slightly more complex, so refer to Figure 2. The read is initiated when the Stamp sends four bytes to the EEPROM. The first three bytes identify the proper address. The second control byte tells the EEPROM to switch to write mode. And finally, the EEPROM sends the data.

The I2C protocol to transfer data is somewhat more complex. At this point, I will refer you to an excellent article written by Jon Williams entitled "I2C Fun For Everyone." This article appears in the May 2002 issue of *Nuts & Volts* and introduces the I2C bus protocol. You will be taught concepts such as the Start/Stop Data Transfer conditions, Master, and Slaves.

User Interface

While we are talking about hard-

ware lets look at the other items added since my first article. An LCD module is used to communicate with the user. Messages are passed to indicate the current state of the program, for example "Manual Mode." The user is also given instruction on what to do to change the current state i.e. "SELECT for main menu." Originally I used an OPTREX display with a byte wide parallel interface. However, a friend pointed out that I had used all of the stamp I/O. There were no openings for adding external sensors. Using a Scott Edwards Electronics ILM-216 serial LCD display solved this problem. It also simplified the source code. The display has a simple physical connection to the Stamp and the communication is easy to implement. Just follow the instructions... The folks at Lynxmotion made the matching enclosure for the display as (Photo 1) which adds a nice finishing touch to the project. Finally a buzzer was added to let the user know that certain functions have been performed without the need to look at the LCD display.

State Machine

This project has three main operating modes:

1. *Manual Mode* — user controls robotic arm
2. *Record Mode* — user controls arm and pushes a button to record a position
3. *Playback Mode* — the arm "plays

Control	High	Low	Data
---------	------	-----	------

FIGURE 1

Control	High	Low	Control	Data
---------	------	-----	---------	------

FIGURE 2

back" the positions entered in the record mode

A Sony Playstation controller is the only user interface used in this project. There are a limited number of input switches on this controller. Since most of the switches were already dedicated to the arm movement functions, I decided to perform mode changes using only the Select and Start keys of the controller. A state diagram (Figure 3) is used to demonstrate the flow of the program between the various operating modes. We don't see this type of logic flow diagram much anymore but it's really useful to illustrate program flow. When you examine the source code for this project, you will notice that each module ends with a Goto statement to another module. Without a state diagram, the code is difficult to read.

A: Startup mode

B: Prompt user to enter Manual mode

C: Prompt user to enter Record mode

D: Prompt user to enter Playback mode

E: Perform manual routine

F: Perform record routine

G: Perform playback routine

The startup mode is used to gracefully initialize the arm. The three user prompts B-D (blue) direct the user to enter an operating mode. In each of these modes, the user is prompted to push Start to enter an operating mode (red) or push Select to proceed to the next mode selection.

A series of Goto commands are used to change from one state to the next.

Startup Mode:

R/C servos are wonderful devices to work with, but they do have one problem. There is no way of telling where they will be when power is first applied. In fact, when power is first applied, the servos normally jerk to the first position commanded by the servo controller. This is really a problem when you have five servos starting all at once.

There is a simple solution to this problem. When power is first applied, simply turn off all the servos. To do this, we will first apply power to the BASIC Stamp. The BS2 then enters in the startup mode. In this mode, it continually commands the SSC-12 servo controller to turn off the servos by commanding them to position 0. When the user applies power to the arm, there is only a slight movement because the servos are immediately commanded to turn off. Finally, once the arm is powered up, the user will command the Stamp to the next operating mode. In the process of changing operating modes, the Stamp will initialize the arm one servo at a time. The order of servo initialization is important to minimize jerk and collisions. The order of initialization is grip, wrist, elbow, shoulder, and finally, base. (Note that the arm is initialized to the

position shown in Photo 1.)

Manual Mode:

The manual mode of operation is unchanged from the previous article. The code reads the Playstation controller and moves the arm based on the user input. The only addition is to respond to the controller's Select button. If activated, the program will vector to state B, as shown on the state diagram.

Record Mode:

The record mode is the most complex of all the operating modes. In this mode, the user manually positions the arm to the desired location. The user pushes the Start button to record the current position of the arm. The Stamp then records the position of the servos and acknowledges the user request by sounding a tone on the buzzer.

The record mode pseudo code is as follows:

1. Initialize the step counter to 0 (number of arm movements completed)
2. Read the PS2 switches
3. If the Select switch is active, goto Step 11
4. If the Start switch is active goto Step 7

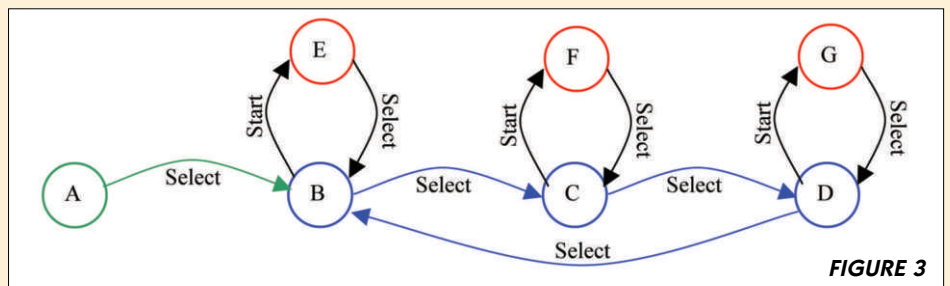


FIGURE 3

5. Move the arm based on PS2 input commands
6. Goto Step 2
7. Store the current position of each servo to the EEPROM
8. Sound the buzzer to let the user know position has been stored
9. Increment the step counter
10. Goto Step 2
11. Store the step counter to EEPROM i.e. store number of arm movements completed
12. Return to user prompts

The first part of the program moves the arm to a new position based on the PS2 input. If the user presses

the Start button, the position of the arm is recorded. To record the arm position, the bytes that indicate the servo positions (i.e., base, shoulder, elbow, wrist, grip) are all sent to the EEPROM. The record position subroutine must also keep track of the number of discrete steps the user has entered. This is very important later for the playback routine.

A small space is reserved at the beginning of the EEPROM to store the number of steps. The program activates a buzzer to indicate that a step has been recorded. This makes setting the positions a bit easier since you don't have to look at the LCD to deter-

mine if the step was recorded. A time delay was added after a step is recorded. This delay function — similar to a debounce function — prevents multiple position recordings when the switch is pressed.

Playback mode:

The pseudo-code for playback subroutine is as follows:

1. Retrieve the number of steps recorded from EEPROM
2. Output the position to the arm
3. If steps played equal steps recorded, then return to user prompts
4. Goto Step 1

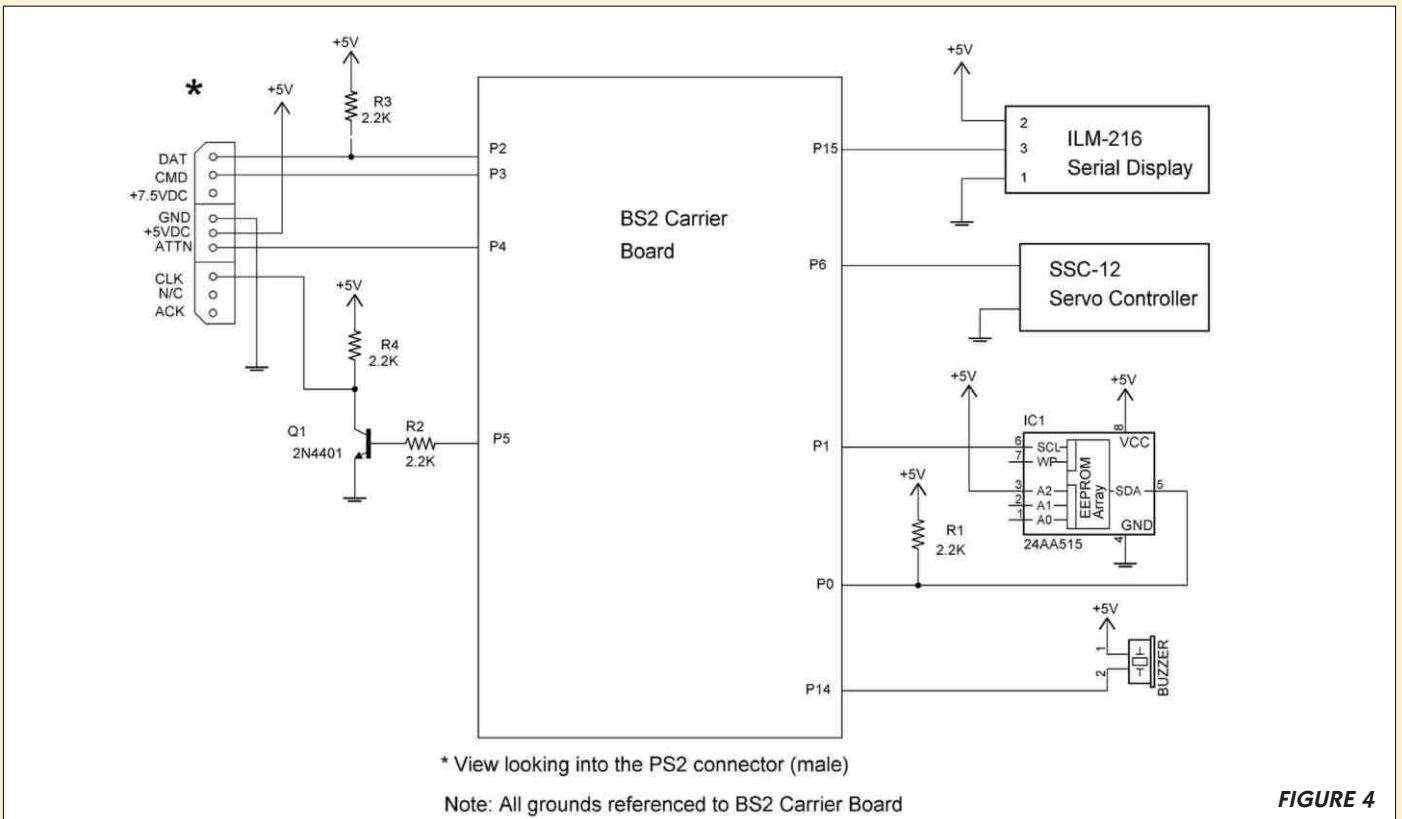


FIGURE 4

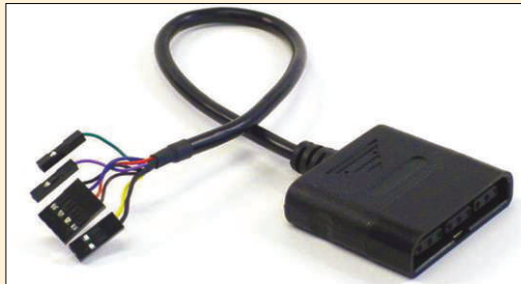
The first step is to retrieve the total number of steps that were entered in the record mode. The number of steps is required so that the playback routine can end properly. The routine then systematically retrieves the servo position and outputs them to the servos. A 1.5 second delay is performed between each step. When all of the steps recorded are complete, the routine returns back to the user prompt.

The SSC-12 servo controller really shines in this application. The SSC-12 is a smart servo controller in that it allows the physical speed of the servos to be controlled. By slowing down the servo, we can limit jerk. This makes the arm movements much more controlled and fluid. Finally, the arm is better able to keep objects in its grip. A typical command to control the servo is shown below, combining speed and servo select into a single term (Figure 5).

Teaching

There is really only one thing you need to know about operating the arm. The arm will take a direct path between any two points. Let's say we want to move the arm from point A to point B. Assume the two points are separated by four inches, and there is a four-inch high wall between them. This move cannot be completed in a single step. If you try, the arm will crash into the wall! Instead, you must make a minimum of three moves.

First, raise the arm five inches (higher than wall). Then move over four inches. Finally, lower the arm five inches.



PSX adapter cable from www.lynxmotion.com
Part #PS2C-01

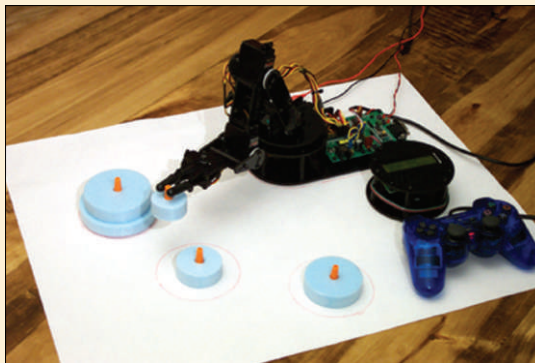


PHOTO 4

Future Improvements

Many challenging aspects of this project still remain. One that immediately comes to mind is editing the "program." A long "program" may consist of many individual movements. For example, the Towers of Hanoi with five disks (Photo 4) requires that the disks be moved 31 times. Each disk movement requires about five individual positions be recorded. That results in a "program" with over 155 arm positions. If you make a mistake at Step 100, you

must start all over again. It is desirable to have the ability to add, delete, or change the entered positions.

The project could use the equivalent of a floppy disk. It would be nice to save different "programs" for different applications. This could be done by swapping out the EEPROM. Another option is to use the Sony Playstation memory cards. I would really like to see someone take on this project. The Sony memory could be very useful to Stamp experimenters. It is nonvolatile, relatively inexpensive, and it is physically durable.

The information could also be sent to a PC where the data could be displayed, edited, and finally downloaded back to the Stamp/EEPROM.

A real challenge would be to display the arm position in X-Y-Z coordinates. This shouldn't be too hard. The length of arm sections doesn't change and is easily measured. We also know the angle of each joint. Using a bit of trigonometry and some vector arithmetic, the X-Y-Z coordinates may be determined.

These are just a few of the possibilities. I trust that this discussion of EEPROM and state machines has spurred your curiosity. Now, go teach your robot some new tricks! **SV**

I/O PIN ATTN SSC-12 select servo

serout 15, \$4054, [255, (SSC12_speed+index), temp]

9600 8N1 speed position

FIGURE 5

Welcome back to our little collection of random bits of robot news from around the world. Got a good story on robots? Email me: news@robotics-society.org If you'd like to get even more robot news delivered to your in-box (no spam, just robo-news), drop a line: subscribe@robotics-society.org

— David Calkins

In one of the greatest scientific breakthroughs since Lee Majors learned to act, researchers at Duke University have taught monkeys to control robotic arms with just their thoughts. The scientists first connected electrodes to the frontal lobes of two monkeys, and then had them move joysticks connected to computer screens. They then trained the computer to process the signals from the monkeys, and then synchronized them to the joystick movement. Then they added a robotic arm and removed the joystick, which the monkeys could control by moving their arm. But the monkeys eventually learned to move the robotic arm without moving their natural arm at all! This is a giant leap that could enable paralyzed people to control "neuroprosthetic" limbs — or taken to the WiFi end, even allow for free-roaming "neurorobots" using brain signals. Can you say *TourBot*?

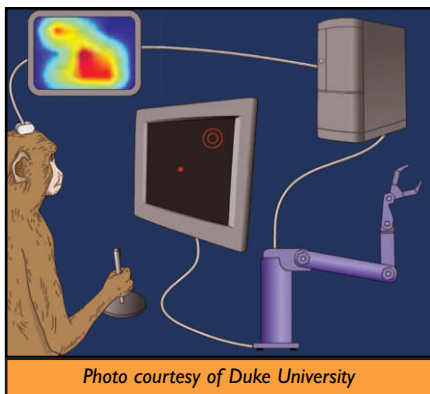


Photo courtesy of Duke University

<http://robotics-society.org/servo/2011>

Robots Go Sailing and Learn to Hang Ten



Photo courtesy of CSIRO

The Commonwealth Science and Industrial Research Organization (CSIRO), Australian Bureau of Meteorology, and the Royal Australian Navy have developed a new project to track the ocean's climates called BLUElink — which uses robots to cycle between the surface and a depth of two kilometers every 10 days. The ocean robots sample conditions in a region thought to be a source of southern Australian rainfall. "This is a key region for the global climate system and the robots will provide our best coverage to begin to understand how the Indian Ocean affects our climate," says CSIRO's Dr. Gary Meyers. Nearly 600 of the ocean profilers have been deployed globally with 3,000 profilers due in place by 2006. Robots in space, robots cruising the ocean, robot kung fu ... Robots get all the FUN jobs.

<http://robotics-society.org/servo/2015>

Or Not ...

CRASAR — The Center for Robot-Assisted Search and Rescue at the University of South Florida —



Photo courtesy of University of South Florida

develops robots to do the stuff humans just don't want to — go into collapsed mines, buildings which have blown up, and other disaster areas. These robots are small, but very smart. Robots from CRASAR have helped with search-and-rescue at the World Trade Center, the Oklahoma City bombing response, and the earthquake in Turkey. Not only can they crawl into places you and I can't, but they can find bodies, and they even have small, inexpensive sensors that can tell if a victim is dead or unconscious, thereby determining if the person is a survivor or has moved on to the realm of magazine editors.

<http://robotics-society.org/servo/2016>

But How to Power Those Robotic Arms?



Photo courtesy of Argonne National Lab

Batteries. Every roboticists' bane. That's why robots aren't as ubiquitous as we'd like — they run out of power too soon. Well, if you're looking for a battery to run your robotic arm or other surgically implanted cybernetics, the end is near. These new lithium-ion batteries are only about 1/35th the size of a standard AA battery, they last much longer than current Lilon batteries, and can be implanted using mini-

mally invasive techniques. The battery is "the smallest cylindrical, rechargeable battery ever made," said Hisashi Tsukamoto, Chief Executive Officer of Quallion, who co-developed the battery with Argonne National Lab. "It provides a long-life power source that overcomes one of the primary hurdles in medical microelectronics." Argonne and the University of Wisconsin are working with Quallion on a next-generation miniature battery using polymer electrolyte chemistry, which developers anticipate will have a lifetime of 10 years or possibly more. I guess that's good news for Walkman users as well ...

<http://robotics-society.org/servo/2012>

Dear Santa: I have been SUCH a Good Boy this Year!



Photo courtesy of Neiman Marcus

Every year, good little boys and girls browse through catalogs picking out the toys they want to find under the tree. When I was a kid, it was a paper version of the Sears catalog. Modern kids have **amazon.com** wish lists. In keeping with the technological increases, Neiman Marcus' current catalog is offering his and hers robots, standing almost six feet tall, to help you with the household chores and day-to-day problems you're bound to

have if you can afford the \$400,000.00 duo — such as greeting the mayor at the door. Made by International Robotics (??), they promise to help you carry your groceries into the house, respond empathetically to humans, and be fully programmable. The usual wireless camera is included, although I'm a bit skeptical as to the AI. But then again, I still can't get my Aibo to sit on command.

<http://robotics-society.org/servo/2014>

Robots Don't Need Guns — They Know Kung Fu!

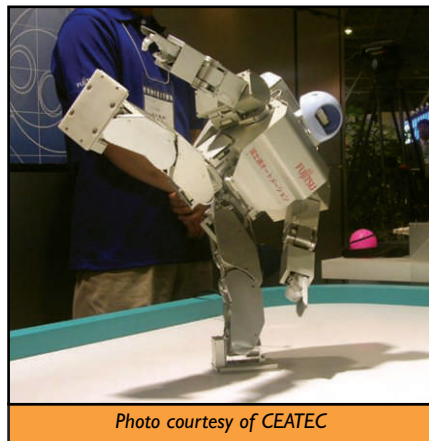


Photo courtesy of CEATEC

A certain politician should be glad he's retired from playing a robot (at least on screen). At this summer's CEATEC (the Asian version of CES), there were several bipedal robots who could do more than walk — they could stand on their head, navigate stairs, and perform martial arts. Fujitsu showed off the latest version of their biped HOAP (first shown in the US at the most recent RSA show), but this bot has learned some new tricks, specifically the Chinese martial art called taijiquan. It can accurately simulate human movement and control its balance. Unlike many humans (me, for

example), it can also perform difficult feats such as standing on its head. Much like my editor when I miss deadlines, it can even stamp its feet on the ground like a sumo wrestler. Good thing for Arnold he's found a new career.

<http://robotics-society.org/servo/2013>

2nd Annual Asian RoboCon a Success

The United States has FIRST, Asia has RoboCon (Robot Contest). Started last year in Japan, RoboCon jumps around Asia giving each country a chance to host the games — this year in Bangkok, next year in Seoul. Teams from 19 countries participated in the games this year. Like FIRST, the rules change each year. This year's theme was "Takraw Space Conqueror." Students make robots that shoot balls into nine baskets and three nets arranged in a triangular shape. You can win by either shooting balls into all the baskets and the three nets, or by outscoring your opponent. (Gads, you can win by just outscoring the other team?! Memo to Dean and Woody: Simplicity good.) After a series of intense battles, Sawangdandin Industrial and Community Education College, Thailand claimed the 2003 Grand Prix trophy.

<http://robotics-society.org/servo/2017> **SV**



PUSHY
ROBOTS

IT'S ALL ABOUT FRICTION

Friction

$$F = \mu W$$

static

kinetic



by Pete Miles

It is amazing how many people that compete in robot sumo events forget about the main aspect of the game — "pushing" your opponent out of the sumo ring. Most people try to use good software, advanced sensors and electronics, and decoys to win a contest. This does help make the robot look really "smart," but not better at pushing. In the end, they usually lose to a robot that has great pushing capabilities.

This article will explain how to obtain the competitive advantage in the pushing war against other robots. Mini sumo robots will be used as the primary example since there are thousands of them competing across the world.

But all of the information presented here is applicable to all robot sumo weight classes, Antweight (one pound robots) combat robots, or any other type of a robot that needs maximum pushing capabilities.

Friction

The key to maximizing the pushing capability of a robot is friction. Equation 1 shows a generalized equation that tells you everything that is important about maximizing pushing

capabilities. The frictional reaction force, F , is also the maximum pushing force of the robot.

The coefficient of friction, μ , is the main topic of this article, and W is the weight of the robot. Since the weight of a robot is constant during a match, the only thing that can improve the pushing capability of the robot is to increase the coefficient of friction between the wheels and the sumo ring (arena surface which is formally called a Dohyo). This equation shows that as the coefficient of friction, μ , increases, the robot's maximum pushing force, F , increases (assuming the motors don't stall).

$$F = \mu W$$

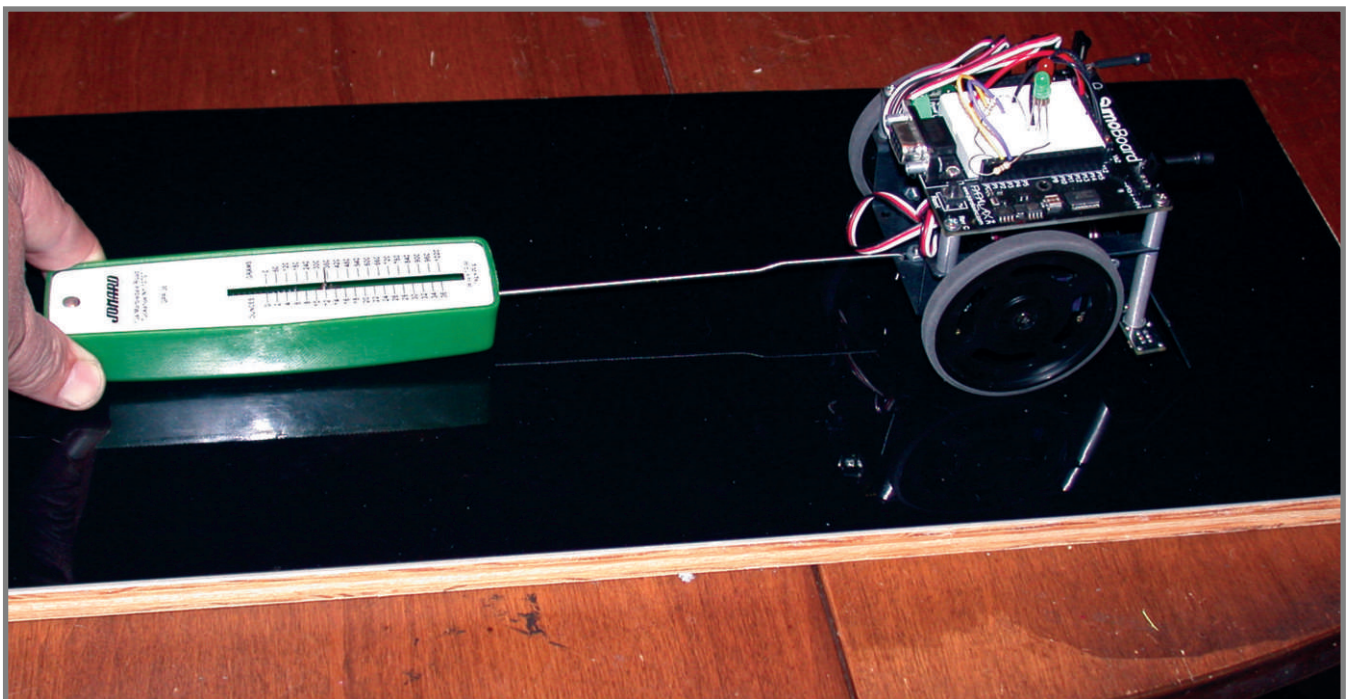
The three primary types of friction that have the greatest effect on the overall pushing capability of the robot are: Static, Kinetic, and Molecular/Adhesion. Static friction is what prevents objects from sliding across a surface. Kinetic friction is what resists an object when it is sliding across a surface. For hard, non-deformable objects, the static and kinetic reaction forces are only a function of what the object's materials are



made from and the normal forces pressing the two objects together. In this case, the weight, W , of the robot.

Since most tires are made from some type of soft, compliant material, molecular/adhesion friction properties come into play. This is where the material deforms into all of the microscopic nooks and crannies in the surface, and requires more energy to be pulled out of — or pulled across — those tiny surface imperfections. One way to think of it is that it takes more energy to move a wheel over a rock/speed bump than across a flat surface. The molecular/adhesion effects occur at the microscopic level where there are millions of tiny speed bumps trying to resist objects from sliding across the surface. Soft, compliant wheels take advantage of this to improve the overall coefficient of the wheel's friction.

FIGURE 1. Directly measuring the static and kinetic coefficients of friction.



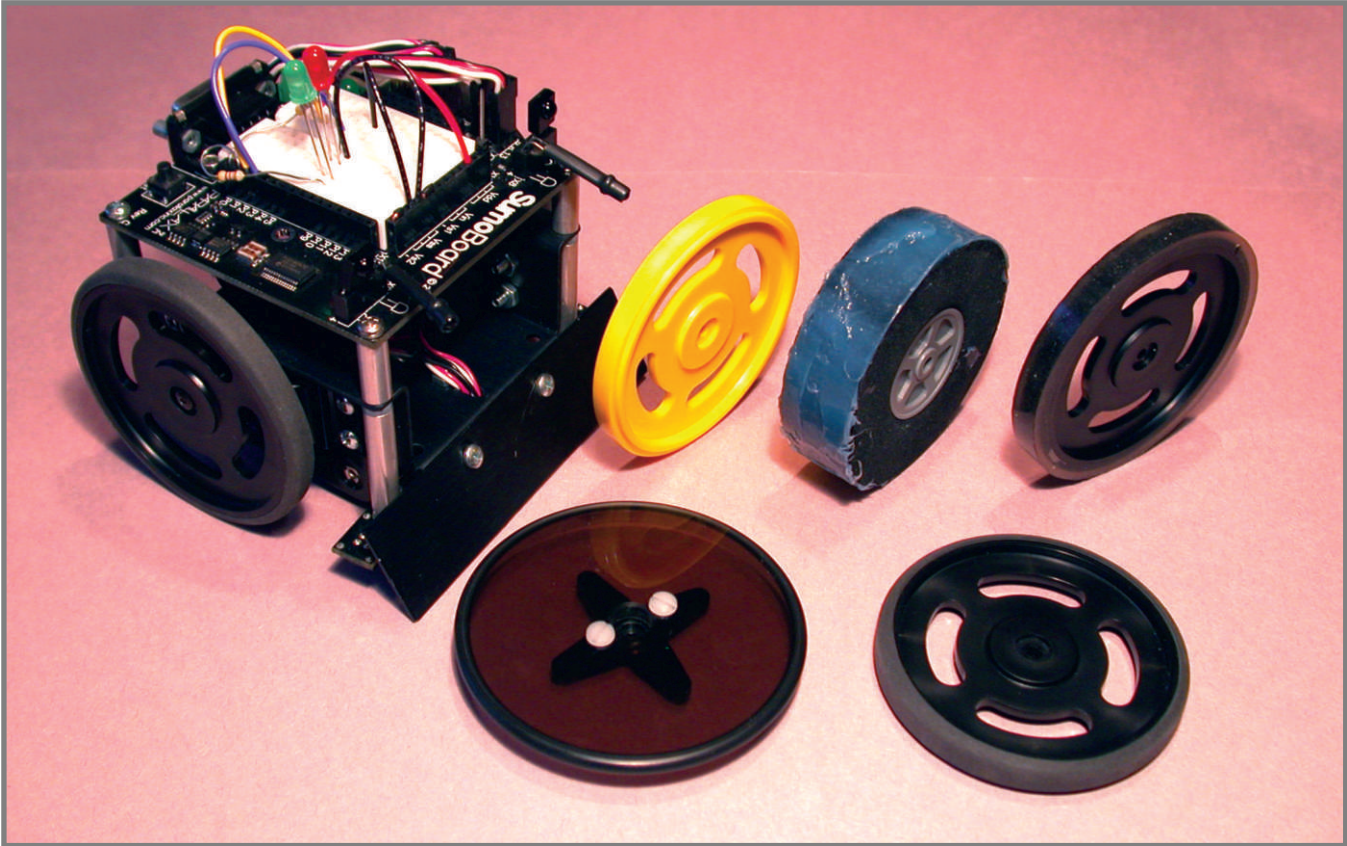


FIGURE 2. SumoBot with various wheels: (top, L to R) solid plastic, silicone coated foam, rubber band, (bottom, L to R) O-ring, polyurethane tire on plastic.

One of the things that makes molecular/adhesion friction different from classical static and kinetic friction is that it is very dependent on the surface areas that are in contact with each other. The larger the contact surface area, the greater the coefficient of friction. The molecular/adhesion coefficients of friction are extremely difficult to calculate, so they are often found by

experiments and presented as a range of values.

One of the easiest ways to measure the static coefficient of friction (including molecular effects) is to use a scale (such as a fishing scale) to pull/push the robot across a horizontal surface (see Figure 1). The highest observed force — at the point when the robot first starts to move — is used to

calculate the static coefficient of friction. From Equation 1, the static coefficient of friction can be determined by dividing the measured force by the weight of the robot.

The kinetic coefficient of friction is found in a similar manner. For sumo robots, there are actually two different types of kinetic friction. One is found by measuring the force required to

TABLE 1. Coefficients of friction of various mini sumo wheels on a vinyl sumo surface.

Material	Static Friction	Kinetic Friction
Hard plastic (SumoBot wheel w/o rubber band)	0.39	0.11 — 0.17
Buna-N rubber (O-ring style wheel)	0.44	0.52 — 0.62
Rubber band on SumoBot wheel	0.73	0.51 — 0.85
Silicone rubber coated foam wheel	1.39	1.26 — 1.44
Cast polyurethane tire on SumoBot wheel	1.53	0.67 — 1.67

slide the robot across a surface at a slow constant speed. The other is to hold the robot stationary, let the wheels spin on the surface, and measure the robot's pulling force. The second one actually gives more useful information, since the robot will be spinning its wheels during a contest.

When including the molecular effects in the kinetic coefficient of friction, there is usually a fairly large range of values that are measured for a particular type of material. This is due to the vibrating nature of soft materials sliding across a surface. The vibration is due to the materials biting into each other, then releasing, then biting, and then releasing, and so on.

The release results in the tire bouncing up in the air. The greater the bounce height or vibration frequency, the greater the drop in the pushing force (i.e., kinetic friction) that is measured. When a wheel is spinning on a surface, it will experience the full range of different kinetic friction values at any given moment. This is one of the reasons why a robot that is pushing well is suddenly pushed backwards, and then regains the pushing advantage.

Table 1 shows a list of measured static and kinetic coefficients of friction for different types of mini sumo tires on an official vinyl mini sumo ring surface. The kinetic friction values were



FIGURE 3. Coating a wheel with silicone, commonly used to make automotive gasket seals.

measured from pulling force when the tires were spinning on the Dohyo. For pushing purposes, the larger the friction coefficient, the greater the pushing capability of the robot. This table shows that solid plastic tires are the worst tires to use, and the best to use are the cast polyurethane tires. Though the polyurethane wheels had the highest static coefficient of friction, they also had the greatest range in the kinetic friction coefficients. This shows that this material could see large momentary reductions in pushing

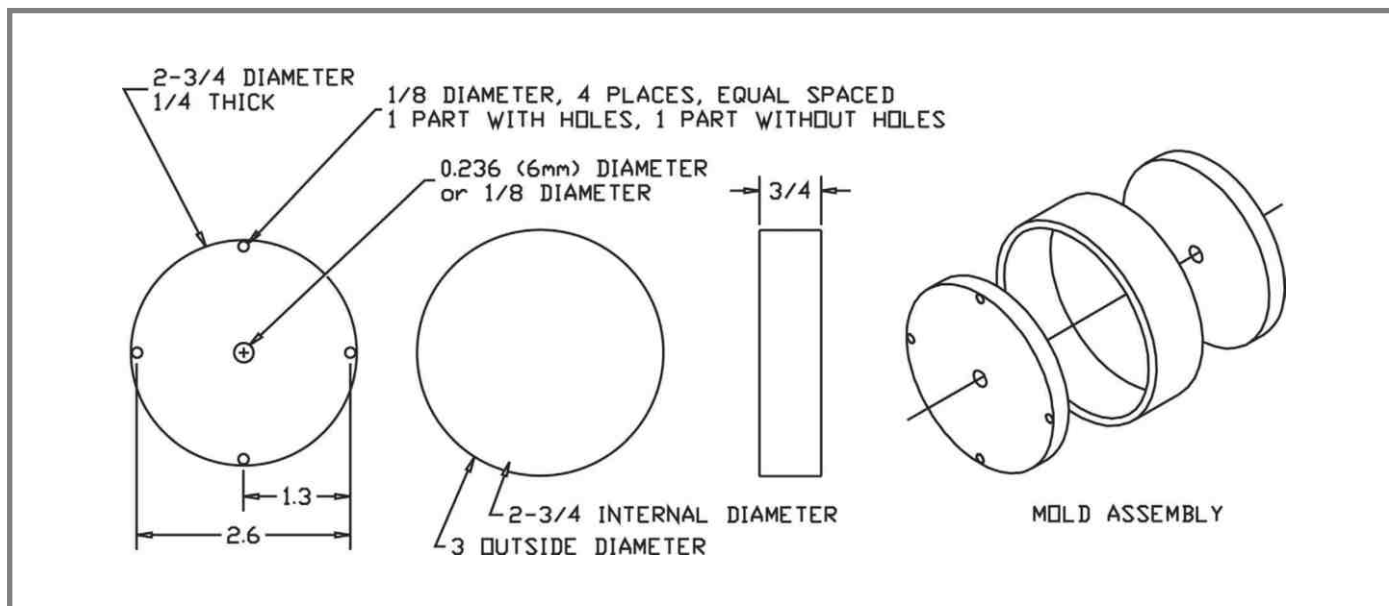
capabilities when the wheels are chattering across the surface of the Dohyo.

The silicone rubber coated and cast polyurethane wheels are generally the best wheels to have on a sumo robot, since they offer the best traction over the other types of wheels. The following sections will describe how to make silicone and polyurethane wheels.

Silicone Coated Wheels

The easiest method to modify an

FIGURE 4. Diagram for SumoBot tire mold.



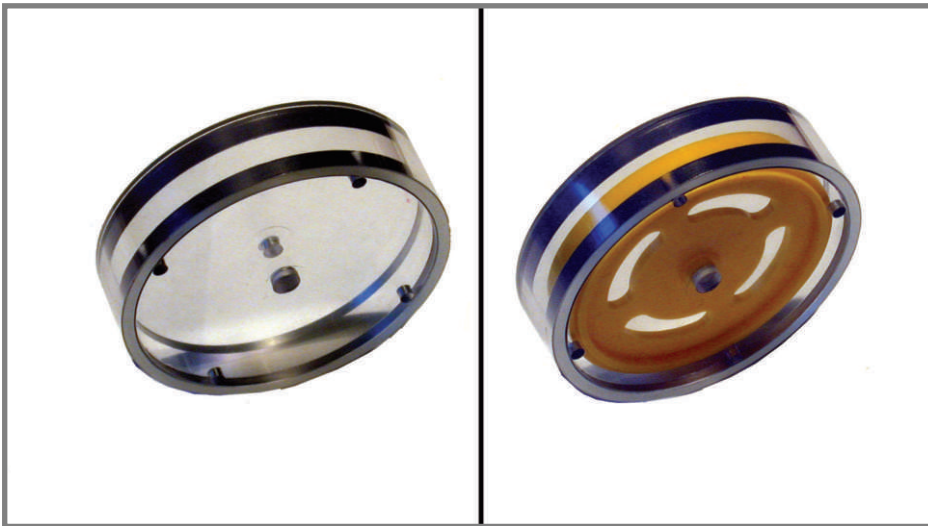


FIGURE 5. The completed mold, without wheel (L) and with the wheel inside (R).

existing wheel into a high traction wheel is to coat the wheel surface with silicone rubber. All that is required is a tube of silicone rubber, such as the RTV (Room Temperature Vulcanizing) silicone rubber that is used to make gasket seals for automotive engines. They can be found at any store selling automotive parts. Spread a small amount of the silicone on a small flat stick such as a popsicle stick, and then spread the silicone on the surface of the wheel. Only a thin coating is needed. Do this in a well-ventilated area since fresh silicone odor is noxious and wear rubber gloves, since this can be very messy. When the wheel is coated, place the wheel on its flat side on an elevated surface to dry. The elevated surface is used to keep the fresh silicone from

touching another surface when drying. Allow a minimum of 12 hours to dry.

Past experience has shown that a mini sumo with silicone coated wheels will out-push any mini sumo that is not using any silicone or urethane enhanced wheels. This is one of the easiest things that you can do to enhance your robot's pushing capability. The finished wheels are generally not pretty to look at, but when you are winning, who cares.

Casting Urethane Tires

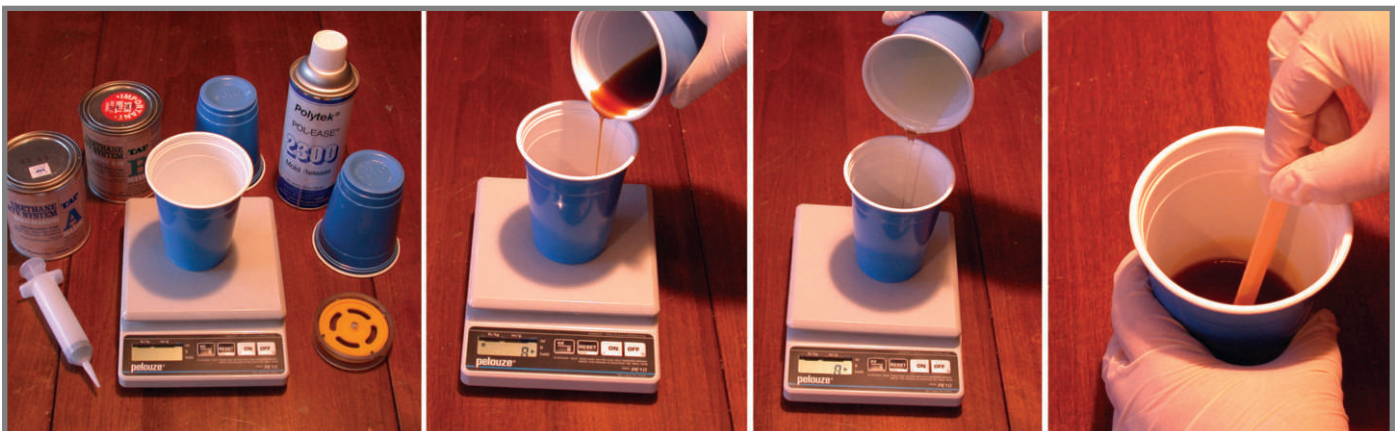
Casting your own tires is often a challenging process, mainly because there is very little information available on how to do it. Table 1 showed that tires made with a soft polyurethane

material yielded the highest coefficients of friction. Because of this, it is the material of choice for the serious competitor. Mold fabrication is one of the trickiest parts of the tire casting process. The shape of the tire is solely dependent on the shape of the mold. The mold needs to consist of several parts, such as an internal wheel geometry and external tire geometry. The mold must be designed for easy disassembly so that the completed tire can be removed without being damaged. The mold must also have injecting ports to allow the liquid casting material to be poured/injected in, and have exhaust ports to allow the air inside the mold to escape as it is being filled. Getting the air out of the mold is often the hardest part of the casting process. Any air left inside the mold results in air bubbles in the final tire.

There are many different ways to make a mold and it's difficult to say which way is the best. Figure 4 shows an example of how to make a mold for casting tires on the Parallax SumoBot wheels. This is a four-part mold. Three of the parts are shown in Figure 4, and the fourth part is the actual SumoBot wheel (with the rubber bands removed, of course).

The best material for this mold is clear so that you can see if there are any bubbles inside the mold. The four 1/8 inch diameter holes near the outside diameter of the 2-3/4 inch diameter disk are only placed on one of the two disks. These holes are for filling and allowing air to escape as the mold

FIGURE 6. Mixing the two compounds together on a scale — ratios are by weight, not volume.



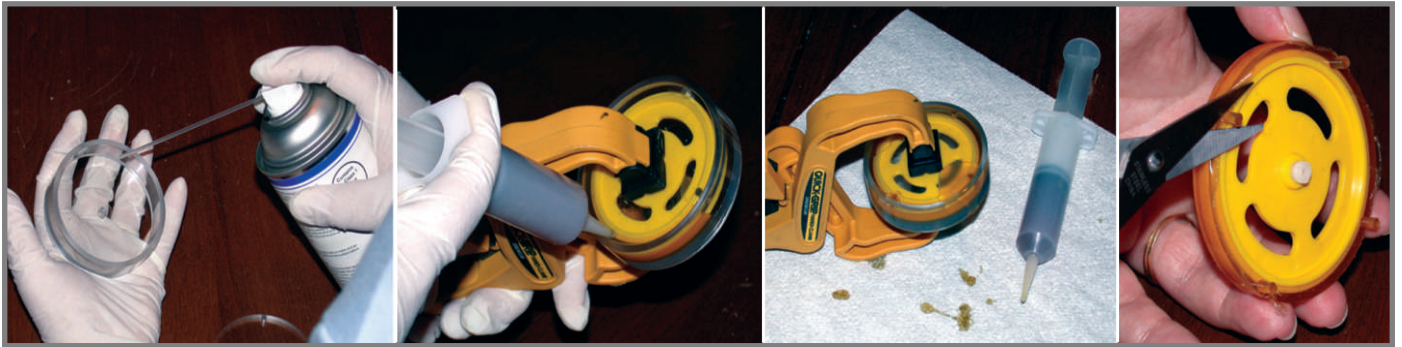


FIGURE 7. Applying mold release (left), injecting the mold with polyurethane, filled mold, and trimming excess flashing and mold spurs (right).

is being filled.

Prior to making the mold, you need to decide how you want to center the wheel inside the mold. This affects the decision on whether to use a 0.236 inch diameter or an 1/8 inch diameter hole in the center of the front mold disk. I like to use the shaft from an old servo to center the SumoBot wheel.

The spline end of the shaft is pressed into the wheel, and the other end fits inside the 0.236 inch diameter hole. The other option is the use a 1/8 inch diameter hole instead of the 0.236 inch hole. Then a one inch long 4-40 screw is used to center the SumoBot wheel inside the mold.

One advantage is that a nut can be used to clamp the entire mold together. Otherwise, an external clamp is required to squeeze the entire mold together. The two 2-3/4 inch diameter disks should fit snugly inside the tube section, but loose enough to be easily pushed out of the disk with the fingers. The looser the fit, the greater the amount of leakage that will occur when the mold is filled. Figure 5 shows a photo of a completed mold with a yellow wheel from Acroname.

The most popular type of casting material for the tires is the two-part liquid (known as Part A and Part B) polyurethane that is used for making

molds. There are many different types that are designed to produce a certain Shore A hardness rating in the final product. (Shore A is an industry standard for measuring the hardness of rubber materials.) The different polyurethane materials can have hardness ranges from 10 to 80.

The smaller the number, the softer the material. A Shore A hardness of 80 is similar to a bowling ball, and a Shore A of 10 is a soft, flexible gummy material. The softer the polyurethane becomes, the higher the coefficient of friction becomes, but it becomes easier to stretch and tear. For mini sumo wheels, a Shore A in the range of 20 to

FIGURE 8. Polyurethane tires on three different colored mini sumo wheels.



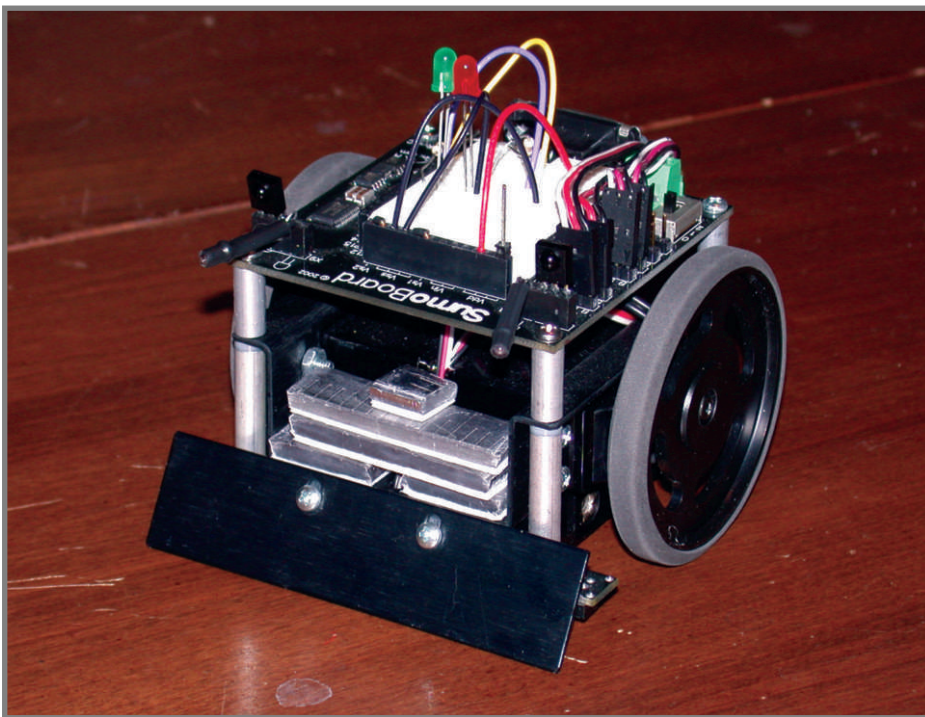


FIGURE 9. Adding lead weights to the front of a Parallax SumoBot robot.

30 should be sufficient. Tires with hardness values less than 20 may be difficult to keep on the wheel because they will be very flexible.

The two compounds are mixed together by weight, not by volume, and they are very sensitive to the exact mixing ratios. (Different products have different mixing ratios that range from 1:1 up to 4:1.) One of the best methods for mixing the two compounds is to use three disposable cups and a scale. Pour a small amount of each compound in two of the cups. Place the third cup on the scale and then zero the scale. Pour a certain amount of one of the Parts in the cup on the scale, say 25 grams if you are making two of the wheels described here. Make sure the volume is more than half the volume you are going to need to make the tire.

Calculate how much of the second compound that will be needed, and then pour it into the cup on the scale until the total weight is achieved. The Urethane RTV Mold Making System, Shore A-30, from Tap Plastics was used in this example. This product is easy to work with, and uses a 1:1 mixing ratio. Slowly mix the two compounds together

to prevent bubbles from forming in the mixture.

Before assembling the mold, spray all of the mold surfaces with a mold release compound, such as Polytek POL-EASE 2300, so that the tire will easily release from the mold, otherwise the tire will be damaged when disassembling the mold. If you want the tire to stick to the wheel, then do not spray any mold release on the wheel's surface. Place the wheel in the mold after the mold release has been sprayed in the mold. Then clamp the two surfaces tightly together so that no casting material can leak towards the center of the wheel.

One of the best ways to fill this mold is to use a bulk syringe to inject the polyurethane into the mold. Hold the mold vertical then inject the polyurethane at the bottom of the mold. Slowly fill the mold until the polyurethane leaks out of all of the air holes (see Figure 7). Then rotate the mold so that all of the air holes are pointed vertically.

This is a very messy process, and there is a good chance that the mold will leak during the filling process. You may have to continually add more

polyurethane to the mold until the polyurethane sets up (starts to harden) if the mold leaks. You have about 15 minutes to fill the mold from the time the compounds are mixed. Otherwise, the polyurethane becomes too thick to be useful.

After the mold is filled, then let it harden for at least 24 hours before removing the tire from the mold. If done properly, the tire should slip out of the mold without any effort. It takes about a week for polyurethane to fully cure.

A successful casting process is a tire that has no bubbles in it, which is very difficult to achieve. But some small bubbles in the tires are okay to have. The last step is to trim off any excess flashing and the spurs from the air and fill holes. Figure 8 shows polyurethane tires mounted on three different colored mini sumo wheels available from Acroname.

Casting should be done in a well-ventilated area, and you should wear gloves since the liquid compounds are respiratory and skin irritants. The liquids smell bad during the mixing process, but the final dry casting has very little odor. Though the casting process can be complicated, it will be well worth the effort when you have a superior pushing robot at your next competition.

One last comment on silicone coated and polyurethane tires — in order for them to work at their maximum capability, they need to be clean. These wheels will pick up every dust particle in the world, and this will significantly reduce the effectiveness of these wheels. It's best to bring cleaning material to a contest, such as baby wipes or facial wipes you get at barbecue restaurants, to clean the tires immediately prior to a match.

Maximizing Weight

The one thing that everyone should do with their mini sumo robots is to make sure that they are at the maximum weight of 500 grams. Equation 1 showed a generalized equation that told you everything that is important about traction. The equation

also shows that as the weight of the robot increases, the greater the pushing force becomes.

Maximizing the weight of a mini sumo robot is probably the easiest thing you can do to improve your robot's pushing capability. The SumoBot kit from Parallax only weighs 360 grams right after assembly (with batteries), which is 140 grams less than the maximum competition weight. A lot of people build these kits and add some really great software where it can dance circles around opponents on the sumo ring, but end up losing to a brainless bot all because the other robot weighed 50 grams more. This is one of the most frustrating things many new mini sumo competitors experience.

The easiest way to solve a weight shortage is to add some lead weights. Lead is very dense, so it won't take up a lot of space on your robot. Lead weights can be obtained from lead fishing weights found at your local sporting goods store, or from an auto tire

store. Another good source is your local hobby store. There they have strips of lead with an adhesive backing that is helpful for sticking on the bottom of your robot.

When your robot is completed, place the robot on a scale, and add the lead weights to the scale until you reach 500 grams. Then all you have to do is find open places to place this lead on your robot. The best place for the lead is at the bottom of the robot and more towards the front scoop of the mini sumo robot (see Figure 9). You want to keep the weight as close to the ground as possible, to minimize the chances of getting tipped over.

Bring a pair of wire cutters with you when you go to weigh-in at a tournament. Many times, the scales at the tournament will read a different weight than what you have at home. If your robot is a little over weight, then you can use the wire cutters to trim off a little bit of the lead weight to reduce the overall weight of the robot.

By applying everything you learned in this article to your mini sumo robot, 3 kg sumo robot, and just about any smaller combat robot, you will have a robot that should have the competitive pushing edge during any contest over robots that are not using these techniques. **SV**

ABOUT THE AUTHOR

Pete Miles is a senior research engineer that develops advanced abrasive water-jet machining technologies and hardware. He is a long time competitor in robot sumo, heavily involved with the Seattle Robotics Society, and he organizes one of the largest amateur robotics events in the US — the Robothon. He is also the author of *Build Your Own Combat Robot* and *Robot Sumo: The Official Guide*.

You can reach Pete Miles at
ajklz5@yahoo.com

Recommended Casting Material

Synair, Inc., www.synair.com
Por-A-Mold 2020
Shore A-20

Tap Plastics, www.tapplastics.com
Urethane RTV Mold Making System
Shore A-30

Polytek Development Corp., www.polytek.com
Poly 74-30 Clear, Shore A-30
POL-EASE 2300 Mold Release

Plastic Mold Materials:
McMaster Carr, www.mcmaster.com
12" x 12" x 1/4" Polycarbonate sheet, P/N 8574K28
3" O.D. x 2-3/4" I.D. Polycarbonate tube, P/N 8585K21
30 cc regular tapered syringes, P/N 7510A655

Mini Sumo Kit
Parallax, Inc., www.parallax.com

Alternative Mini Sumo Wheels
Acroname, Inc., www.acroname.com

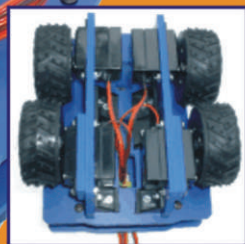
Robot Sumo Rules
Northwest Robot Sumo Tournament
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Robotics Resources:



The Tool Junkie

by Gordon McComb

It's hard to decide which is more fun: building robots or just playing with the tools used to build robots! While it's possible to construct a 'bot with just a screwdriver, the job is made easier with various hand and power tools common to all construction projects. Using the right tool saves you time, and provides a better end-product. And most likely, you'll enjoy the process a whole lot more, too.

In this column, we review some major makers and sellers of tools useful in the robot construction art. Of course, no single column could hope to list every tool from every manufacturer that you could possibly use. Rather, consider these listings representative of the wide array of tools and suppliers available to you.

Tool Categories

Tools can be roughly separated into three main categories: hand, power, and precision.

• **Hand tools** are as their name implies: the bulk of the work effort comes from your hands, rather than a motor or air piston.

The most common hand tools to have in the 'bot shop are: adjustable wrench, electric drill and drill bits, safety glasses/goggles, hacksaw, hammer, locking grip pliers (such as Vice Grips), needle nose and standard pliers, rasps and files, razor knife, screwdrivers, and tape measure.

• **Power tools** are equipped with a motor — usually electric or air, to make them work. Power tools get the job done faster, and are best suited for working with harder materials, like polycarbonate plastic or metal.

The most common power tools for robot building include drill (handheld and drill press), table saw, saber saw, and belt sander. If you have one available, a radial arm saw, scroll saw, or band saw prove handy, as well.

• **Precision tools** are not necessarily for miniatures work; the name implies a level of accuracy useful in constructing complex machinery or drive components.

The two most common precision tools found in the home machinist shop are the lathe and mill. These are available in both manual and computer-controlled (CNC) versions.

Where to Get Tools

Where you buy your tools can influence their type, quality, and price. The usual recommendation is to buy only the best tools you can, but this is not always practical. As necessary, you can purchase low-cost versions of those tools that don't require accuracy or heavy-duty construction.

For the most part, a \$1.00 screwdriver will usually do the job of a \$10.00 one, but may not last as long, or feel as good in your hands. Shop wisely, and you can better afford all the tools you need, while still maintaining reasonable quality for those tools that need it.

For basic inexpensive tools, try the selection at the local "dollar store," if one is nearby. In these stores, everything is priced at or near \$1.00. I've found perfectly good tape measures, flat and Phillips blade screwdrivers, utility knives, and other basics at the local dollar stores.

For wrenches, pliers, and similar tools, I prefer a better quality. Unless you're building combat robots or other heavy duty machines, you probably don't need mechanic's-grade tools; though very good quality, they can be quite expensive. Even a small set of open-end mechanic's wrenches can cost over \$100.00. Name-brand hand tools available at hardware stores, online, and department stores — Craftsman and Crescent — are

representative of this group.

Tool Sources

Campbell Hausfeld
www.chpower.com

Campbell Hausfeld is one of the premier names in home and shop air tools. CH's air tools include: air hammers, drills (including reversing type), ratchets, screwdrivers, sanders, nailers, and staplers. I use two reversing drills, keeping either drill bits or screwdriver bits in them, depending on what I'm doing. Quick disconnect couplers allow for fast tool changes.

Clisby Miniature Machines
www.clisby.com.au

Small precision lathes and milling machines (for wood and metal) at surprisingly low prices. Useful for working with lightweight materials such as brass, aluminum, and milling plastics. These are small, and are well suited for machining little parts — like couplers and linkages — for your robot.

Elenco Electronics
www.elenco.com

As noted on their website, Elenco is a major supplier of electronic test equipment and educational material to many of the nation's schools and hobbyists. Sold through distributors. The website is a good source for learning what's available.



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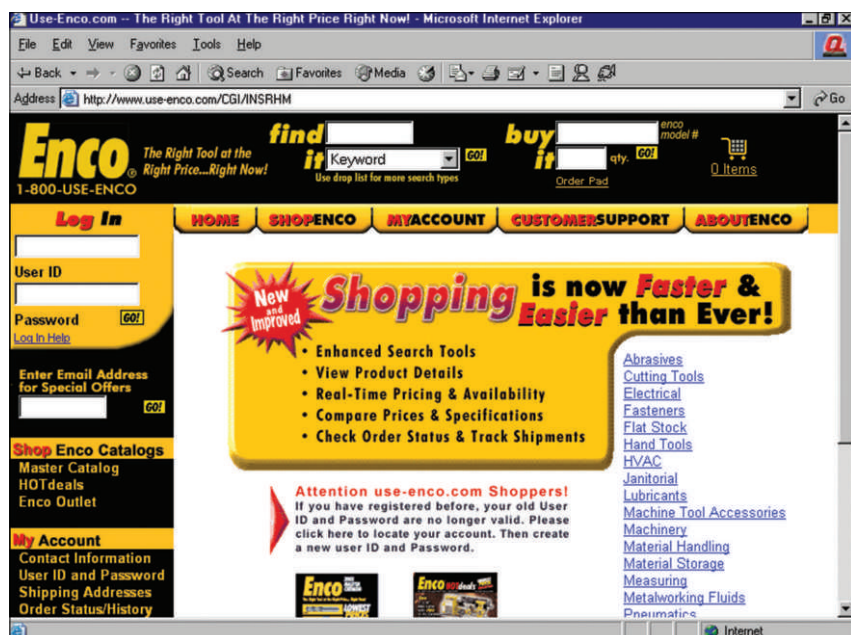
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- Optional built-in line-follower mode; easily activated
- Optional Basic Stamp II / Stamp Stack brain module
- Optional PIC 16f677 brainboard with breadboard space (available '04)
- Optional Atmel Mega8L brainboard with breadboard space (available '04)



Enco offers hand, power, and precision tools for home, shop, and small business use. Prices are reasonable, and free shipping is often provided.

Enco Manufacturing Co. www.use-enco.com

Enco is a premier mail order source for shop tools, power tools, hand tools, production tools (lathes, mills, hydraulic presses, metal brakes, you name it), bits, saws, casting materials, plastics, hardware (door and cabinet), fasteners, tooling components, ACME rods and nuts, welding equipment and supplies, and *lots* more. They print a master catalog and send out sales catalogs on a regular basis. The sales catalogs contain some real bargains.

FDJ On Time www.fdjtool.com

For the jewelry maker, FDJ On Time is a "one-stop shop" for miniature jewelry tools, casting equipment, soldering supplies, electroplating gear, cleaners, mold making equipment, and wax working tools. Offers an extensive list of investment casting supplies (furnaces, investment, etc.). A printed catalog is available.

Flashcut CNC www.flashcutcnc.com

CNC mini mills and lathes. Based on Sherline products. Complete and retrofit.

Grizzly Industrial, Inc. www.grizzly.com

Woodworking and metalworking

tools. Large showrooms in Bellingham, WA, Muncy, PA, and Springfield, MO.

Harbor Freight Tools www.harborfreight.com

Harbor Freight built a business on selling value-priced tools, much of it "off-brand," but still perfectly workable. (I still regularly use the Chinese-made drill press I bought from Harbor Freight over 20 years ago.) They offer hand and power tools, pneumatic tools, and even metal mills and lathes. Retail stores in selected areas of North America; check the website for a store locator.

HobbyCNC www.hobbycnc.com

Plans and basic starter kits for building your own CNC router. Their "CNC package" includes three stepper motors, stepper motor controller electronics, and assorted hardware (minus the case).

Irwin Industrial Tools www.irwin.com

Irwin makes the famous Vise-Grip locking hand tools, along with several other well-known brands, below.

This is a good site for learning about common shop tools, and how they're used. Products are available through retailers and much of the material on their web pages is market-

ing fluff. However, they do offer informative "solutions and tips" for selected tools.

Jensen Tools, Inc. www.jensentools.com

Tools for electronics — basically everything you need, including hand-held meters and scopes, precision hand tools, shop supplies, soldering stations, you name it. Wide selection.

MAXNC, Inc. www.maxnc.com

Makers of desktop CNC mills and lathes.

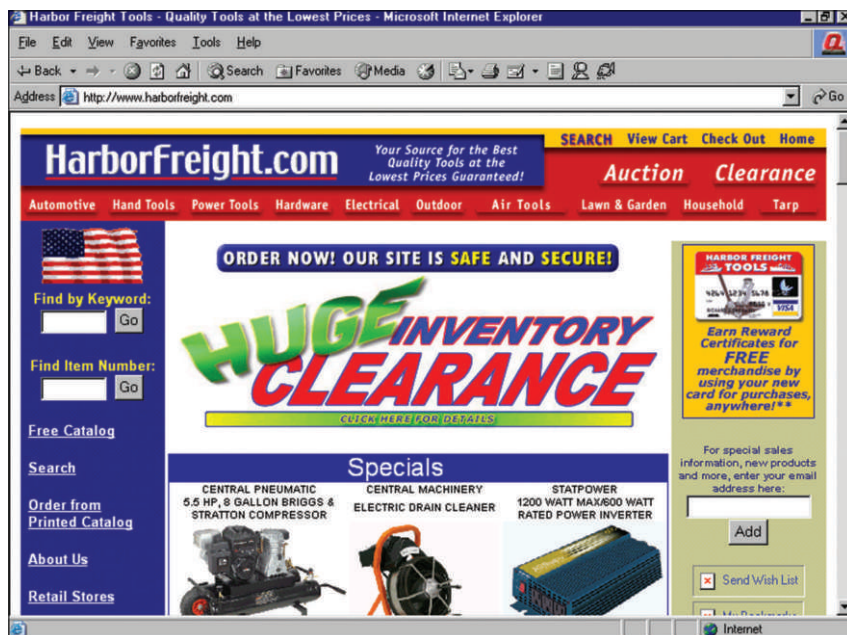
MicroKinetics Corporation www.microkinetics.com

Desktop mills and lathes, as well as full-size production machines. Stepper motors, servo motors, and motor controllers for CNC.

Micro-Mark www.micromark.com

Micro-Mark is about precision tools. They sell precision and miniature tools of all descriptions, including desktop mills and lathes, as well as hand tools, bits, and other accessories, small hand-operated motorized tools, casting supplies, and raw metal, plastic, and wood (well, it's not really "raw," it's in sheet, tube, or other manufactured form).

**Harbor Freight —
online and local
stores — sells low-cost
tools for the budget
conscious.**



Minicraft

www.minicrafttools.com

Sellers of Minicraft precision power tools (sanders, saws), as well as hand tools.

Northern Tool & Equipment Co.

www.northerntool.com

Northern Tool & Equipment Catalog Company is a supplier of products to the DIY crowd, whether they be small businesses, auto shops, or home tinkers. Northern's main product lines are generators, small engines, pressure washers and hand, air, and power tools. The company is also known for stocking thousands of mechanical parts, including:

- Casters, from small to heavy-duty
- Plastic, metal, and other construction materials
- Shaft couplers, including Lovejoy three-piece jaw couplers
- Go-Kart parts (such as centrifugal clutches, chains, sprockets, and wheels)
- Hydraulic cylinders, pumps, and hoses

Penn State Industries

www.pennstateind.com

Hand and motorized tools (mostly for wood). The Library section contains information about the tools (many in Adobe Acrobat PDF format), as well as plans for home-based projects (no

robots that I could find ...).

RB Industries, Inc.

www.rbiwoodtools.com

RBI makes scroll saws, wood planers, and drum sanders. Their Hawk brand scroll saws are the notable product here, as they can be used to cut out precision parts in wood, plastic, and even metal. I've had one of their 16-inch scroll saws for over a decade, and it's one of my most cherished tools. These things are expensive, but

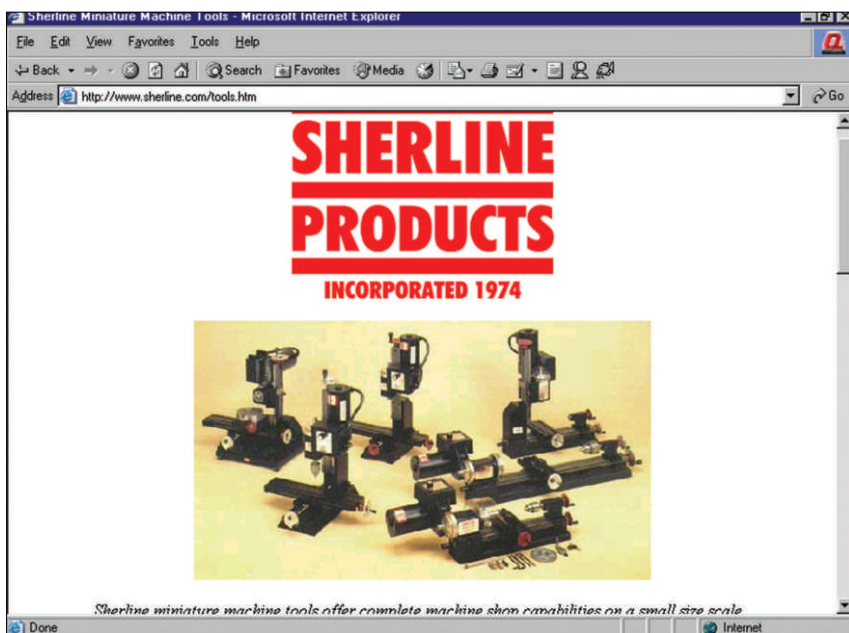
they last a life-time.

Rockler Woodworking and Hardware

www.rockler.com

Rockler carries hand and power woodworking tools, hardware, and wood stock (including pre-cut hardwood plywoods). Among important hardware items are medium-sized casters, drop-front supports (possible use in bumpers or joints in robots), and drawer slides.

An advertisement for the 'OCTOBOT SURVIVOR' robot kit. It features a woman with long brown hair and sunglasses holding a large, orange, octagonal robot shell. The shell has 'Bradbury' written on it. The background is a vibrant purple. Text on the left side reads 'TM & © MMIII Mondo-Tronics, Inc.'. The main title 'OCTOBOT SURVIVOR' is in large, yellow, block letters. Below the title, there is an 'UPDATE: A NEW BREED OF ROBOTIC AGENT' section. The 'MISSION' is described as performing 'special robot ops' like wall following, light seeking, object avoiding, random wander, and then - 2) it automatically seeks out its charging station & recharges itself. Unique! The 'OPTIONS' section lists two add-on ports, a Stamp 2 socket (control it with your own code) & much more. The 'RECOMMENDATION' states: 'An advanced robot kit that strives to keep itself "alive!" → Send yours into action today! ←'. At the bottom, the website 'WWW.ROBOTSTORE.COM' is displayed in large, yellow, block letters.



Sherline makes and sells desktop mills and lathes, in several variations and sizes. A favorite of the model-maker.

S·K Hand Tool Corporation www.skhandtool.com

Wrenches, ratchets, and other great hand tools. Buy a set of these when you're young, and they'll grow old with you.

Sears, Roebuck & Co. www.sears.com

Sears sells lots of stuff, but of prime interest to robot builders is their tools. They used to have a big catalog sales department, but didn't see the Internet coming, and got rid of it. You can buy Sears tools at their local stores, from Bob Vila's TV commercials, and online and mail order. Sears also operates specialty hardware and home improvement stores, Sears Hardware, and Orchard Supply Hardware.

Sherline Products www.sherline.com

Sherline is a premier maker of miniature "desktop" lathes and vertical mills. They're a staple in home machinery shops, and there is an active trade in parts and accessories on eBay and other online auctions. Sherline doesn't offer CNC versions or retrofits of their products (though they sell them "CNC ready"), but many other companies offer retrofit kits. So you can purchase a manually-operated

lathe or mill now, and upgrade it to CNC should you wish to automate your production.

Shopsmith, Inc. www.shopsmith.com

Shopsmith makes the famous all-in-one woodworking tool that combines table saw, sander, lathe, horizontal boring machine, and drill press.

TAIG Tools www.taigtools.com

TAIG Tools makes small desktop ("micro") mills and lathes. Versions of the machines can be manually operated or connected to your computer for CNC. Sold through dealers. Be sure to check out their regular Internet specials. You can get a nice mill or lathe for less than you think. Note that several companies offer CNC retrofits for the TAIG line; TAIG also provides CNC versions of some of their tools. See also MicroProto

Systems (www.microproto.com) for CNC versions of TAIG mills and lathes.

Toolsforless.com www.toolsforless.com

Power tools and hand tools. Stocks some 50,000 power and hand tools, hardware, parts, and accessories.

Vermont American Corporation www.vatool.com

Tool manufacturer: Saw blades, screwdriver bits, router products, drill bits, abrasives. Browseable web catalog; products are available through retail stores like Lowe's and Home Depot.

Woodworker's Warehouse www.woodworkerswarehouse.com

Woodworking tools, fasteners, hardware, accessories, and supplies. Local retail stores in the Northeast, and offers online sales.

About the Author

Gordon McComb is the author of the best-selling *Robot Builder's Bonanza* and the *Robot Builder's Sourcebook*, both from Tab/McGraw-Hill.

In addition to writing books, he operates a small manufacturing company dedicated to low-cost amateur robotics, www.budgetrobotics.com. He can also be reached at robots@robotoid.com

Zona Tool Company www.zonatool.com

Small precision tools for hobbies and crafts. Product line includes clamps, pin vices, small hack saws, jeweler's saws, metal and oxide shaping tools (replacement bits for Dremel and similar tools), and sanding blocks. Zona tools are most commonly found at the local hobby store. **SV**

APPETIZER

Some Observations About Intelligence, Social Intelligence, and Artificial Intelligence

by Allan J. Comeau

Intelligent Knowing

One of my undergraduate teachers at the University of Massachusetts, Edmund Gettier, wrote a three page paper in 1964 that put previous theories of epistemology into disarray. In "Is Justified True Belief Knowledge?" Gettier showed that even reasonable and true assertions could be, in the end, factually faulty. Offering a series of counterexamples to the then-accepted rules of knowledge, Gettier demonstrated that the proof of real knowledge relies on a great deal more than appearances, even, at times, compelling appearances.

For example, Smith swears he saw Jones at a party, because Jones is a tall, thin man who always wears a particular plaid jacket. Unbeknownst to him, Jones's brother was also at the party, wearing an identical jacket. The assertion "Jones was at the party" is, in fact, true. Smith was justified in thinking that he was, but he was never in direct possession of the evidence.

"I know what I see" now becomes subject to a bit of Cartesian tautology-busting — "I know what I see and what I have inferred from what I see," this informed seer might opine, "but I now realize that the truth of what I see may actually not be exactly what I have inferred." Shades of Socrates, who was the first to teach by disputation — and so much for trusting one's own perceptions.

Philosopher Michael Polanyi, writing on the subject of personal knowledge, distinguishes between tacit or subsidiary knowledge or awareness and knowledge of the immediate, focal type. The more one's focus is "out there," on the objects or actions before one, the less attentive one becomes to the corresponding internal and/or mental contents and processes that are at play, but lie momentarily out of awareness.

For Polanyi, tools — that is, objects taken or fashioned for one or another purpose — are seen as agentive, self and body extenders. Existentialist-ontologist philosopher Martin Heidegger describes tools as interwoven with human being. We only become aware of tools, as such, when they are broken or when we are looking for something to do with them. Once in the hand, a hammer becomes part of oneself, a part suitable for pounding or removing a nail. Too much awareness of my computer's individual keys and I'm lost in reverie, but not very productive. Preferably, my contact and awareness of the keys slip away and withdraw from my awareness as I continue typing, and my mind stays focused on emerging thoughts, possible sentence constructions, and decisions about what and how to communicate with

you in this essay.

The relics of our ancient ancestors, signs of tools and adaptations to changing seasons and climes, remind us that our existence and station in the food chain are most probably due to a combination of such factors as having larger and increasingly usable cerebrums, standing with erect posture, having opposable thumbs, and making and living within social groupings with roles and assignments, allowing other group members to develop different useful skills and perform selective tasks.

At this point in time, computers and all their progeny are mostly seen as tools of human agency. The more advanced and independent they become, the more subsidiary they become to our conscious awareness, but, when they break or malfunction, they need to be repaired along with our other tools.

What is Intelligence?

What is intelligence? From a joke or a boasting challenge that has not quite yet died, "intelligence" used to be "what is measured by IQ tests," but it isn't anymore.

To gather and to choose — these are the root components of the word "intelligence," from which sense we also perceive, understand, know, and reason. This word has been in the English vocabulary since the early fourteenth century, derived from Latin and then French usage.

The guiding principle of most intelligence testing is the idea that relevant, domain-specific, test items can be designed and administered and that correct responses can be statistically ranked, demonstrating valid and reliable differences between different people and their abilities.

IQ pioneer David Wechsler defined intelligence as a multifaceted aggregate, "the global capacity to act purposefully, to think rationally, and to deal effectively with the environment."

The Wechsler's intelligence scales test for general information, some knowledge of history, vocabulary (the most robust subscale having the highest correlation with the overall score), language abstractions (for example, "How are an orange and a pear alike?", number recall (forward and backward, the latter requiring storage and reversal of the number in memory), block-building by design (spatial reasoning and construction abilities), symbol to number coding and mazes (spatial reasoning and problem solving), and abilities to discern errors and story sequences in picture cards (responsiveness to subtle social and physical informational cues). Interestingly, differences in scores between the verbal

(vocabulary, information, etc.) versus performance (using motor skills) sets of subtests are statistically predictive of gross differences in left-right hemispheric functioning.

Recognizing that traditional intelligence measures fail as accurate predictors of real-world achievement, Yale psychologist and current American Psychological Association president, Robert J. Sternberg proposed a triarchic theory composed of knowledge acquisition, performance, and metacomponent processes. Performance components consist of the perceptual, short- and long-term storage, and calculations dimensions; knowledge-acquisition components are principally involved in gaining and initial storage of new knowledge; metacomponents, considered the most important, determine which strategies will best serve the knowledge context or situation. Sternberg's model would remove the abstraction implicit in office-based test measures and seek indications of intelligence in human adaptation to the challenges of living in the real physical and social world.

Artificial Intelligence (AI)

The quests for artificial intelligence are many. One might say that anytime a person can make an object act or extend into the world and accomplish his ends, a bit of artificial intelligence is born.

The American Association for Artificial Intelligence offers the following definition of the AI enterprise, "the scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines."

Alan Turing, who gained fame for his work in decoding the Nazi enigma encryption device — an important contribution to the Allied WWII effort — was perhaps the first theoretician to actively work on artificial intelligence problems. Turing suggests the following experiment: Place a human and a computer in a room, out of the questioner's view. Invite the questioner to type his or her query and send the question into the room. Then have both the computer and the human answer the question, sending the result via teletype to the questioner. If the questioner cannot tell which answer came from whom, then we can conclude that the computer is possessed of intelligence. We've already assumed that the human is smart, to answer that objection. There are some objections to this test, particularly Berkeley philosopher John Searle's "Chinese Room," where he concludes that computers at best simulate understanding and they may be useful for studying understanding, but they do not, themselves, understand.

Stanford's John McCarthy is credited as the first to coin the term "artificial intelligence." McCarthy proposed that common-sense reasoning should be the goal of AI research, defining intelligence as "the computational part of the ability to achieve goals in the world."

The initial AI enterprise has included a number of interrelated challenges: pattern recognition programs, such as speech recognition, and typing software, as well as fingerprint and face-recognition capacities; high-speed information processing, using fast computers that can simulate very complex natural phenomena, such as the weather or war-

fare scenarios; information-gathering and data-management capacities, such as might be found in robotic and deep space exploration; and problem-solving and reasoning devices, such as chess-playing machines that can challenge a Grand Master or medical diagnosis programs and information delivery systems that can simulate the reasoning of expert diagnosticians are just a few of the many areas where computational device technologies are being developed within an AI framework.

Artificially Intelligent Observations

It makes perfect sense to me that AI devotees began their quest to build machines that perform tasks in a manner indistinguishable from human agency in matters of informational and even behavioral outputs. This initial leap takes its shape in our own tendency to obsess, to appreciate, and even "love" the things that we have created, whether for our amusement, for our health, or even for profit.

Although people have imagined their toys to have human qualities for ages — this may even be a throwback to our animistic prehistory, when all things were believed to possess life — the driving force behind the current round of animation is the idea that any biological system, including human thought, can be emulated by sequences of binary functions, written as software, running inside sufficiently fast hardware. With such a computer, or series of computers, various human abilities, including perception, movement, handling and manipulation of objects, and even decision making could (are presently in development) and will likely be realized.

The number of neurons in an "average brain" is estimated to be about one hundred billion. Since each neuron may be connected to several thousand other neurons, the number of possible connections between all of these neurons is mind numbing. While I find it unlikely that each possible neuronal connection would have its own unique knowledge connection or unit, the full range of possible interconnected neuronal, thus brain states, is still staggering. In the face of the near impossibility of ever constructing a machine of that complexity, AI developers have opted for a more modest and practical model of interrelated intelligence subsystems.

Marvin Minsky, whose 1985 book, *The Society of Mind* illustrates some of the conceptual possibilities of specifications of layers of agencies (intellective functions), each either controlling each other or performing some desired task, from perception to stacking blocks to making bridges, and so on, demonstrates that suitable theories of intelligence, including reasoning, can be developed, using interconnected hierarchical components. In the end, whether such thinking will grant his device a soul, or make his Pinocchio into a real boy, is yet to be seen.

Is an Artificial Social Intelligence Possible?

Is intelligence interactive, or is it an "in one head" sort

of phenomenon? One of the cardinal tenets of science is *the principle of verifiability*. In the scientific enterprise, personal or subjective knowledge is considered useful only as hypotheses that must be independently verified by one's colleagues. In this sense, all scientific knowledge is essentially social. It would seem useful then to consider whether AI research and the knowledge that thus derived should not only be verifiable by separate teams, but also by other artificial intelligences?

We now know from neurodevelopmental studies that children learn much of their own emotional language and inner self-sense through their relationships with others. Self and emotional learning occur substantially through paired communication and mirroring. Children learn that they are loved by the availability of a loving gaze, word, or touch. Children learn this best when loving interaction is unconditional and consistent (not necessarily constant, though.) Thus, we humans must learn what is most human from each other, even though we may learn a great deal else on our own, even factoring in the problems of verifiability. In a sense, our mirrored response to our children's distress can be seen as a type of social verification, with the parent's voice answering, "Yes, I too see that you are hungry. Here's a bottle and let me hold you while you eat."

Can Machines be Programmed to be Emotionally Intelligent?

Using "If A, then B" logic, no, I do not think so. Our own emotional experience, often juxtaposing or even blending seemingly incompatible states and thus expressive and behavioral conclusions, informs us that formal "yes or no" logic has its limitations. To begin to describe emotional blends and other non-discreet states, a type of modal or multimodal logic would be necessary. Such a logic could be informed by research on emotional states and their interrelationships, as described in Richard Lazarus' *Emotion and Adaptation*. At M.I.T., Rosalind W. Picard heads the Affective Computing Research Program. Her work on pattern recognition and human-computer interaction is summarized in *Affective Computing*.

Danish philosopher Soren Kierkegaard declared the existential manifesto that human reality cannot be subsumed into a logical system. Mathematician Kurt Gödel's incompleteness and inconsistency theorems proved logically that using a fixed set of axioms, there would always be some propositions which cannot be proven, forcing a super ordinate level, itself containing unprovable propositions. Who is it that we humans turn to, when we are in certainty or in doubt? In the end, perhaps our machines will probably turn out as compassionate and as humanly compatible as we ourselves are capable of being.

A BBC newsflash recently reported the anticipated late 2003 arrival of "the world's most powerful computer." Built by IBM and named ASCI Purple, this computer is designed to work at a speed of 100 teraflops, able to carry out 100 trillion operations per second. Designers expect another computer, reportedly operating at twice that speed, in

another two years. Just yesterday, I read about Virginia Tech's successful pairing of over two thousand Apple® computers, enabling perhaps the third fastest supercomputer in the world — at a price of just over five million dollars. This is, of course, a bargain, as the one at the Lawrence Livermore labs costs over one hundred million dollars.

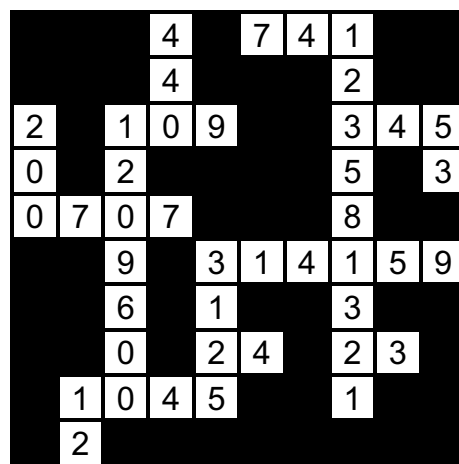
Just as we find little evidence for the existence of a fully functioning human being, perfect in all respects, I see no compelling need to require a perfectly programmed machine, in all human respects. Just as we are able to each reach our own personal best in some or several domains of study or performance, some reaching and realizing higher than the rest, so we should elevate our expectations for our machines, our smart programs and our robotic friends. If we can become attached to them, as they are in some manner, reflections of ourselves, perhaps we can learn to care for, nurture, and some day, love them. Perhaps, also, some of that love will rub back on ourselves and our conduct towards one another. What is love? Looking towards, waiting, moving towards, touching softly, protecting from harm, giving what is needed, wanting the best for...?

If, as some scientists believe, the brain can operate at about 10,000 trillion operations per second, perhaps we are not so far away from Steven Spielberg's AI character, "David," played by Haley Joel Osment. Of course, if we were to build David today, he'd probably have to be connected to a server the size of a football field. When future androids go offline, just what subroutines might they be running? **SV**



About the Author

Licensed psychologist Allan J. Comeau, Ph.D., is on the clinical faculty at UCLA and a former president of the Inland Southern California Psychological Association. Visit his website at **www.drcomeau.com** or Email questions directly to yourmindmatters@hotmail.com



Here is the solution to the numeric crossword printed last month in *SERVO*. Isn't that a great ratio for generating pi? - **Editor Dan**

EVENTS CALENDAR

Send updates, new listings, corrections, complaints, and suggestions to: steve@ncc.com or FAX 972-404-0269

Most of us are too busy during the holiday season to spend much time with our robots. Accordingly, this tends to be a slow time for competitions. But, there are a few smaller, local events during December. All are student competitions and two are specifically for LEGO robots.

Things pick up a bit in January, at least if you live in India, with the potentially huge TECHFEST 2004 in Bombay. In addition to sponsoring this year's Yantriki robot competition, TECHFEST will include an international contest for rope-climbing robots and a wide range of engineering competitions. About 15,000 students are expected to attend.

There's a lot more action in the next few months including the APEC MicroMouse Contest scheduled for February in California. March brings both the highly anticipated DARPA Grand Challenge and the annual AMD Jerry Sanders Creative Design Contest. And, in April, we have the national championships for FIRST, as well as the SAE Walking Machine Challenge.

— R. Steven Rainwater

December 2003

6 Boonshoft Museum LEGO Mindstorms Robotics Competition
Boonshoft Museum, Dayton, OH — Local competition for the FIRST LEGO League. Winners move on to the state competition.

www.boonshoftmuseum.org/special_events.php3

6 Penn State Abington Robo-Hoops
Penn State Abington, Abington, PA — Yes, this is autonomous robot basketball. Each robot has 60 seconds to make up to four baskets by shooting or dunking.

www.ecsel.psu.edu/~avanzato/robots/robo-hoops.htm

13 LEGO MY EGG-O Robotic Egg Hunt
Great Lakes Science Center, Cleveland, OH — Bi-annual student contest of the Case Western Reserve University Autonomous LEGO Robotics Course.

www.eecs.cwru.edu/courses/lego375/

13 RSA Holiday Robot Games And Expo
Fort Mason, Bldg. C, San Francisco, CA — Warm up your soldering irons! International displays and competitions of robots from NASA through Fujitsu.

www.robotics-society.org

January 2004

17 MURC
Lakewood, CO — Radio-controlled vehicle combat brought to you by the Mid US Robotics Club.

www.murconline.com

24-26 Yantriki TECHFEST 2004, IIT
Bombay, India — This is a huge technical festival involving over 15,000 students from 750 colleges across India. There are a lot of other technical contests in addition to the robotics events.

www.me.iitb.ernet.in/yantriki or www.techfest.org

February 2004

22-26 APEC MicroMouse Contest
The Disneyland Hotel, Anaheim, CA — If you can't catch the Japanese MicroMouse event, this one should be just as interesting with some very advanced robots.

www.apecconf.org/2004/APEC04_Home_Page.html

March 2004

12-13 AMD Jerry Sanders Creative Design Contest
University of Illinois at Urbana, Champaign, IL — This year, robots will play Tetris by forming a completed puzzle out of the nine standard Tetris shapes on a 36 foot square playing field.

<http://dc.cen.uiuc.edu/>

13 DARPA Grand Challenge
Los Angeles, CA — The autonomous LA to Vegas cross-country, off-road race for a one million dollar prize. Not your average robot contest.

www.darpa.mil/grandchallenge

13-14 Manitoba Robot Games
Manitoba Museum of Man and Nature, Winnipeg, Manitoba, Canada — This interesting assortment of robot events includes mini sumo, Japanese sumo, a robot tractor pull, atomic hockey, and robo-critters.

www.scmb.mb.ca/mrg.html

20-21 RSA ROBOlympics
Fort Mason, Herbst Pavillion, San Francisco, CA —

Courtesy
of



Possibly the largest robot competition of 2004 and includes robot fighting, FIRA robot soccer, a bipedal race, BEAM, LEGO Mindstorms, mini-nano sumo, and more. Over \$10,000.00 in prize money is offered.

www.robotolympics.net

28 University of Florida Student Robotic Competition

Univ. of FL Conference Center, Gainesville, FL — This is the only robot contest you'll see where the robots are required to obey Asimov's three laws as part of the rules!

plaza.ufl.edu/niezreck/Robots_Co_mpetition_2004.html

April 2004

15-17 FIRST Robotics Competition

Georgia Dome, Atlanta, GA — The national championship event for the FIRST student robot competitions. It's the largest FIRST event of the year and is open to the public.

www.usfirst.org

16 Carnegie Mellon Mobot Races

Wean Hall, CMU, Pittsburgh, PA — The 10th annual occurrence of the now famous CMU Mobot race. Autonomous robots race to complete a complex course, passing through 18-inch finish gates along the way.

www.cs.cmu.edu/~mobot/

Surplus Sales of Nebraska

www.surplussales.com

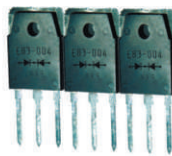
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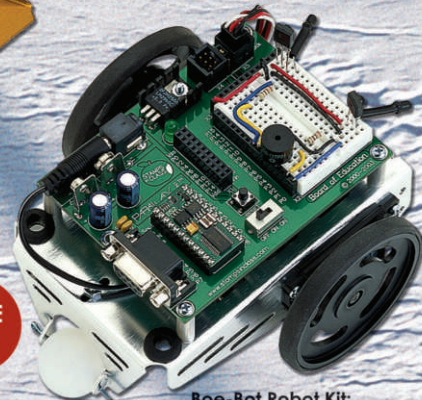
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